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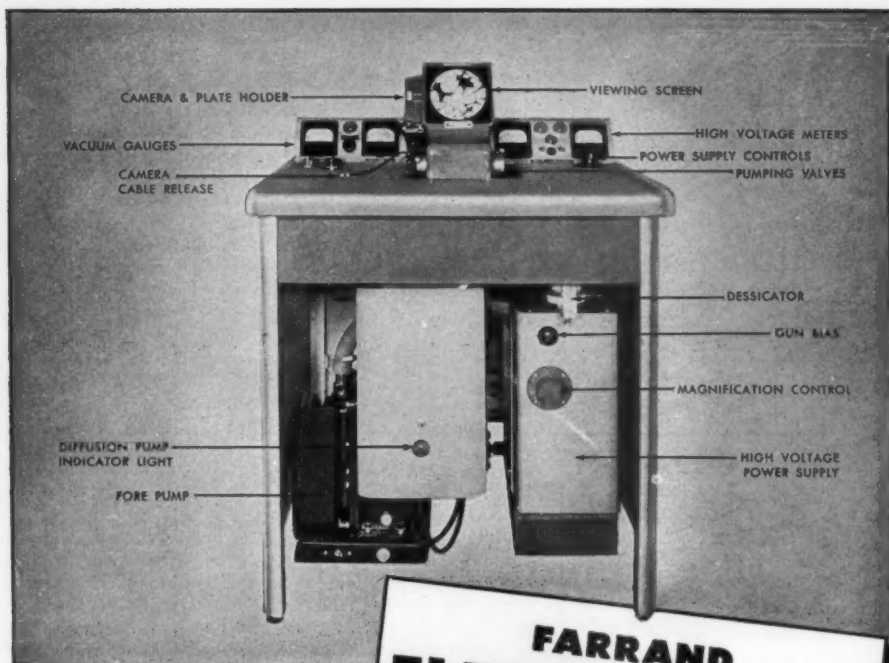
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Acoustical Oscillations of Flames

THE pulsation and oscillation of flames in burners have acquired scientific and economic significance for combustion technologists, engineers in power plants, and designers of aircraft and missiles, because the phenomenon may cause many types of trouble. Or, conversely, it can be harnessed to accomplish desired ends. Two widely separated developments have brought flame oscillation to the forefront of scientific investigation: the increased popularity of basementless, ranch-type homes, and the technological evolution of pulse-jet, jet-turbine, ram-jet, and rocket engines. Problems within power plants have also heightened the interest.

Residential furnace manufacturers have received complaints from builders and homeowners about the noise and vibration caused by their equipment. Flame pulsation in burners located in utility rooms of basementless houses has produced disagreeable noises and has caused adjacent walls to vibrate. In certain instances homeowners have experienced an "uncomfortable feeling" during the operative phase of the burner cycle, apparently caused by inaudible pulsations.

In large burning systems, such as in power plants, oscillations from flames sometimes cause vibrations violent enough to threaten damage to structures, and costly changes have been tried to blanket or reduce such vibrations. Acoustical oscillations in the afterburners of jet turbines and in ram-jet and rocket engines have caused difficulties ranging from noises intolerable to the human ear to vibratory destruction of engine parts. Oscillations in certain rockets and missiles, on the other hand, are believed to increase combustion efficiency.

Both industry and military are cognizant of the need to know more about flame oscillations and are sponsoring research on the subject. Fundamental studies are being conducted at Battelle Institute for the Flight Research Laboratory, Wright-Patterson Air Force Base. In addition, Battelle has been the site

of research sponsored by several manufacturers of industrial and home-heating equipment. Four lines of investigation have been followed. Attempts have been made to (1) determine the various types of oscillations that may occur in combustion systems; (2) explain the mechanism, or sequence of events, responsible for causing each type of oscillation; (3) determine the effect of oscillations on other components of the system; and (4) develop means for either suppressing or amplifying a particular oscillation.

Some burners emit sound consisting of relatively pure tones, of the same type as produced by a pipe organ. Oscillations from these burners have been explained by elementary acoustical considerations. In some instances, an analysis of the system has been used to predict the occurrence of oscillations and to determine what steps can be taken to suppress or amplify them. Effective suppression of the organ-pipe type has been attained with quarter-wave tubes and Helmholtz resonators of the proper size.

Burners may also produce tones that are not immediately recognized as of the organ-pipe type because they are so close to the low Helmholtz frequencies. The predicted frequency may be as much as eight times greater than the observed frequency. High-speed motion pictures in such a burner show drastic, periodic changes in flame shape. Oscillations that often cause trouble in large combustion systems, such as oil-fired locomotives or industrial furnaces, may not be primarily of acoustical origin. Here the flame may act as an amplifier, raising the intensity of pressure fluctuations to an intolerable level.

In their studies of oscillations in burners, Battelle scientists have used microphone systems, tape recorders, sonic analyzers, sound-level meters, and motion picture cameras. It seems probable that research will provide the information needed to eliminate most of the troubles caused by flame oscillations. The deliberate use of the phenomena in certain types of burners to improve combustion efficiency is another probable positive gain that will come from the research.

ABBOTT A. PUTNAM

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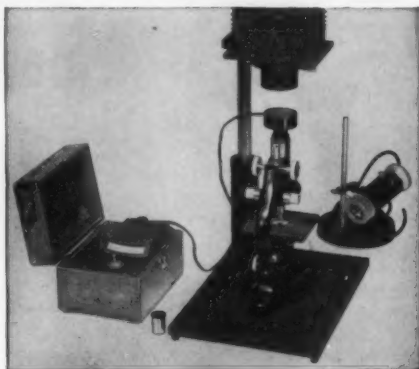
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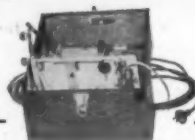
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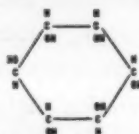


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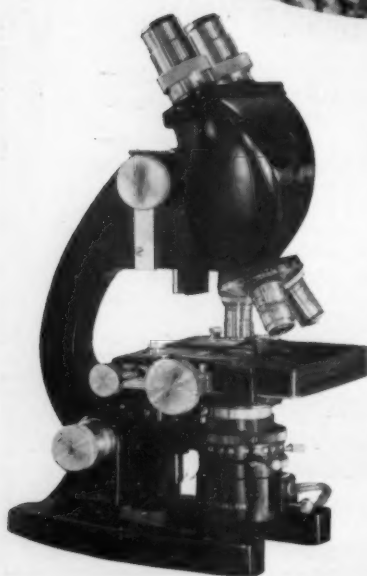


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The New Immigration Law

William A. W. Krebs, Jr., and Carmel P. Ebb¹

National Science Foundation, Washington, D. C.

ON DECEMBER 24 the McCarran-Walter Immigration and Nationality Act of 1952² went into effect. For the first time since 1917 the United States now has an integrated code of laws covering this broad field. The new act revises and brings up to date laws that have not been basically altered since shortly after the end of World War I, but that were modified by a series of measures passed after 1940 and particularly between 1948 and 1952, as U. S. immigration policy reacted to growing public concern over the threat of international Communism.

Since the official printing of the McCarran-Walter Act occupies 120 single-spaced pages and weighs perhaps a quarter of a pound, it may be fortunate, from the point of view of scientists, that only a relatively small number of its provisions are of special interest to them. These include, however, some of the controversial issues in the legislation. It is the purpose of this article to provide a brief digest of these provisions.

In immigration law, persons coming to this country are either immigrants or nonimmigrants. Immigrants are those who come to stay; nonimmigrants are those who come to visit. Since a number of the outstanding scientists in the U. S. today arrived as immigrants, science has a stake in those parts of the law that control admission for permanent residence. The new law retains, with certain changes, the national origins quota system, established in 1924, under which the number of persons of any nationality who may enter the U. S. as immigrants in a given year is determined on the basis of the number of persons of that national origin who resided in the U. S. in 1920. Within the limitations of this quota system, scientists are likely to be in a preferred group under the new law, since the first 50 per cent of the annual quota for any country is set aside for the admission of specially trained or skilled individuals.

Those provisions that control the admission of foreign scientists as visitors have, however, a more direct impact on science in this country because of their effect on the travel of foreign scientists to this country and the exchange of scientific information. These provisions are found in § 212(a) of the Immigration and Nationality Act, which lists classes of aliens in-

eligible to receive visas and required to be excluded from the U. S. Section 212 begins by requiring the exclusion of aliens who are feeble-minded, insane, mentally defective, addicted to drugs, convicted criminals, paupers, and the like. There are 28 excluded classes of this kind. In addition, the act requires the exclusion of three additional classes, described in § 212(a) (27), (28), and (29). These three provisions, which deal with the acceptability of both immigrants and visitors on political grounds, had their origin in legislation that was enacted shortly before the conclusion of World War I, and that excluded all persons advocating the violent overthrow of government. Except for relatively minor amendments made by the Alien Registration Act of 1940, they existed without substantial change for thirty years, until 1948, when they were expanded and restated in part. Further expansion and restatement occurred in the enactment of the Internal Security Act of 1950, when the provisions for exclusion on political grounds were given the form in which, with minor changes only, they have been carried into the Immigration and Nationality Act of 1952.

With some oversimplification it may be said that they exclude from entrance into this country the following classes of aliens:

1. Those who are believed by a consular officer or by the Attorney General to be seeking entry into the United States to engage in sabotage or attempted overthrow of the government, or to engage in other activities prejudicial to the public interest or endangering the safety or security of the United States (§ 212(a) [27] and [29]).
2. Those who are, or in the past have been, affiliated in a broad sense of the word³ with the Communist Party or any other organization that seeks to establish a totalitarian form of government in the U. S.⁴ (§ 212(a) [28]).

Exclusion on the first ground, often called the safety and security provisions, is based on a finding by an administrative officer (the consul or the Attorney General) as to the activity in which an individual alien is likely to engage after entry into the United States. This conclusion could be based, in part, on evidence of membership, past or present, in the Communist Party or a number of other subversive organizations, but it seems to require much more. Exclusion

³ Under the law any person who contributes or lends money to be used for advocating a doctrine is presumed to advocate the doctrine, and any person who gives or lends money to any organization is presumed to be affiliated with the organization.

⁴ Until recently, the law excluded past or present members of any totalitarian organization; i.e., any Communist or fascist organization. The law now effective excludes only members of such organizations advocating the establishment of a totalitarian government in the United States.

¹ The following descriptive article on those features of the new immigration law of particular interest to scientists was prepared at the request of the AAAS by William A. W. Krebs, Jr., general counsel of the National Science Foundation, and Carmel P. Ebb, consultant to the foundation. Mr. Krebs and Mrs. Ebb are both members of the New York Bar. The statements are those of the authors and not of the National Science Foundation.

² Public Law 414, 82d Congress, 2d Session.

on the second ground, past or present political affiliation, does not require a finding by the administrative officer as to the activity in which the individual alien is likely to engage; it rests on the general conclusion embodied in the law that political affiliations of the kind described are likely to result in activities prejudicial to the public interest, without further proof of intent or motive.⁵

⁵ Section 212 (a) (28) provides for the exclusion of:

"Aliens who are, or at any time have been, members of any of the following classes:

"(A) Aliens who are anarchists;

"(B) Aliens who advocate or teach, or who are members of or affiliated with any organization that advocates or teaches, opposition to all organized government;

"(C) Aliens who are members of or affiliated with (i) the Communist Party of the United States, (ii) any other totalitarian party of the United States, (iii) the Communist Political Association, (iv) the Communist or any other totalitarian party of any State of the United States, of any foreign state, or of any political or geographical subdivision of any foreign state, (v) any section, subsidiary, branch, affiliate, or subdivision of any such association or party, or (vi) the direct predecessors or successors of any such association or party, regardless of what name such group or organization may have used, may now bear, or may hereafter adopt: PROVIDED, That nothing in this paragraph, or in any other provision of this Act, shall be construed as declaring that the Communist Party does not advocate the overthrow of the Government of the United States by force, violence, or other unconstitutional means;

"(D) Aliens not within any of the other provisions of this paragraph who advocate the economic, international, and governmental doctrines of world communism or the establishment in the United States of a totalitarian dictatorship, or who are members of or affiliated with any organization that advocates the economic, international, and governmental doctrines of world communism or the establishment in the United States of a totalitarian dictatorship, either through its own utterances or through any written or printed publications issued or published by or with the permission or consent of or under the authority of such organization or paid for by the funds of, or funds furnished by, such organization;

"(E) Aliens not within any of the other provisions of this paragraph, who are members or affiliated with any organization during the time it is registered or required to be registered under section 7 of the Subversive Activities Control Act of 1950, unless such aliens establish that they did not have knowledge or reason to believe at the time they became members of or affiliated with such an organization (and did not thereafter and prior to the date upon which such organization was so registered or so required to be registered have such knowledge or reason to believe) that such organization was a Communist organization;

"(F) Aliens who advocate or teach or who are members of or affiliated with any organization that advocates or teaches (i) the overthrow by force, violence, or other unconstitutional means of the Government of the United States or of all forms of law; or (ii) the duty, necessity, or propriety of the unlawful assaulting or killing of any officer or officers (either of specific individuals or of officers generally) of the Government of the United States or of any other organized government, because of his or their official character; or (iii) the unlawful damage, injury, or destruction of property; or (iv) sabotage;

"(G) Aliens who write or publish, or cause to be written or published, or who knowingly circulate, distribute, print, or display, or knowingly cause to be circulated, distributed, printed, published, or displayed, or who knowingly have in their possession for the purpose of circulation, publication, distribution, or display, any written or printed matter, advocating or teaching opposition to all organized

The Attorney General is given discretion (§ 212[d] [3]) to modify this general conclusion in the case of any particular individual seeking admission as a visitor. Upon the recommendation of a consular officer or the Secretary of State, and if he believes it to be in the public interest, he may admit a visitor who would otherwise be excluded solely because of a past or present political affiliation of this type. Each exercise of this authority must be reported in detail to the Congress. No discretion exists for the admission of persons excluded under the safety and security provisions.

government, or advocating or teaching (i) the overthrow by force, violence, or other unconstitutional means of the Government of the United States or of all forms of law; or (ii) the duty, necessity, or propriety of the unlawful assaulting or killing of any officer or officers (either of specific individuals or of officers generally) of the Government of the United States or of any other organized government, because of his or their official character; or (iii) the unlawful damage, injury, or destruction of property; or (iv) sabotage; or (v) the economic, international, and governmental doctrines of world communism or the establishment in the United States of a totalitarian dictatorship;

"(H) Aliens who are members of or affiliated with any organization that writes, circulates, distributes, prints, publishes, or displays, or causes to be written, circulated, distributed, printed, published, or displayed, or that has in its possession for the purpose of circulation, distribution, publication, issue, or display, any written or printed matter of the character described in paragraph (G);

"(I) Any alien who is within any of the classes described in sub-paragraphs (B), (C), (D), (E), (F), (G), and (H) of this paragraph because of membership in or affiliation with a party or organization or a section, subsidiary, branch, affiliate, or subdivision thereof, may, if not otherwise ineligible, be issued a visa if such alien establishes to the satisfaction of the consular officer when applying for a visa and the consular officer finds that (i) such membership or affiliation is or was involuntary, or is or was solely when under sixteen years of age, by operation of law, or for purposes of obtaining employment, food rations, or other essentials of living and where necessary for such purposes, or (ii) (a) since the termination of such membership or affiliation, such alien is and has been, for at least five years prior to the date of the application for a visa, actively opposed to the doctrine, program, principles, and ideology of such party or organization or the section, subsidiary, branch, or affiliate or subdivision thereof, and (b) the admission of such alien into the United States would be in the public interest. Any such alien to whom a visa has been issued under the provisions of this subparagraph may, if not otherwise inadmissible, be admitted into the United States if he shall establish to the satisfaction of the Attorney General when applying for admission to the United States and the Attorney General finds that (i) such membership or affiliation is or was involuntary, or is or was solely when under sixteen years of age, by operation of law, or for purposes of obtaining employment, food rations, or other essentials of living and when necessary for such purposes, or (ii) (a) since the termination of such membership or affiliation, such alien is and has been, for at least five years prior to the date of the application for admission actively opposed to the doctrine, program, principles, and ideology of such party or organization or the section, subsidiary, branch, or affiliate or subdivision thereof, and (b) the admission of such alien into the United States would be in the public interest. The Attorney General shall promptly make a detailed report to the Congress in the case of each alien who is or shall be admitted into the United States under (ii) of this subparagraph."

Apart from the discretionary power of the Attorney General, which can be used to permit the entry of visitors but not immigrants, there are provisions that permit the entry, either as visitors or as immigrants, of persons who would normally be excluded because of their past political affiliations. Such persons need not be excluded if their affiliation was involuntary, or occurred when the alien was under 16 years of age, was by operation of law, or for purposes of obtaining employment, food rations, or other essentials of living. An alien who has, for at least five years prior to his application for a visa, actively opposed the doctrine, program, principles, and ideology of the organization in question may be admitted if there is a finding by both the consular officer and the Attorney General that admission would be in the public interest. Each such admission must also be reported to the Congress by the Attorney General.

Administration of these provisions is placed in the hands of the consular officers so far as the issuance of visas is concerned, and of the Attorney General, who acts through the Immigration and Naturalization Service of the Department of Justice, so far as admission to this country through ports of entry is concerned. Before granting a visa, the consular officer must satisfy himself that the applicant does not come within any of the classes of excluded aliens discussed above. Exercise of discretion to admit otherwise inadmissible aliens requires action by both the Attorney General and the Secretary of State or a consular officer. The issuance of a visa by a consular officer ("an endorsement made on a passport by the proper authority denoting that it has been examined and that

the bearer is permitted to proceed . . .," *Merriam-Webster*) does not guarantee passage through the port of entry in the continental United States, which is under the jurisdiction of the Attorney General. The law places an independent responsibility on the immigration officer at the port of entry to determine the admissibility of all persons coming into the country.

In recent months, several suggestions have been made in the press, in scientific publications, in testimony before the President's Commission on Immigration and Naturalization, and in the Commission's report published early in January⁶ for the revision of the laws governing the admission of visiting scientists. Among these proposals was the setting up of special procedures for the speedy processing of applications by scientists for admission as visitors. More fundamental is the suggestion that a distinction be made between the substantive and administrative requirements for temporary admission and the requirements for admission for permanent residence. In line with this proposed distinction, it has been suggested that the criterion requiring exclusion of an alien visitor might rationally become present sympathetic association with a foreign subversive organization rather than, as now, affiliation at any time in the past with such an organization. An additional proposal has been the development of a definitive listing of subversive organizations, the character of which as such has been publicly identified by an authoritative body or officer after due investigation.

⁶ *Whom We Shall Welcome*, Report of the President's Commission on Immigration and Naturalization. Washington, D. C.: GPO (1953).

Leigh Page: 1884-1952

W. F. G. Swann

Bartol Research Foundation of the Franklin Institute, Swarthmore, Pennsylvania

ON SEPTEMBER 14, 1952, death claimed Leigh Page, professor of mathematical physics at Yale University, a renowned scholar and a great teacher, who left his mark on the creative realm of American mathematical physics.

Leigh Page was born October 13, 1884, at South Orange, New Jersey. He was the son of Edward Day Page, merchant, and Cornelia Lee Page. He had his early schooling in New York City, but thereafter his whole life was associated with Yale University, where he obtained his B.S. degree in 1904 and his Ph.D. in 1913.

Starting his teaching as an assistant in physics in 1910, he progressed until, in 1922, he was appointed full professor of mathematical physics—a chair first

held by Willard Gibbs—and he held this position until his death.

Page published sixty or seventy scientific papers and was the author—in some cases a co-author—of six books, of which the best known are probably his *Introduction to Electrodynamics* and his *Introduction to Theoretical Physics*. Both books have had a profound influence in the development of many of America's leading mathematical physicists.

His research interests were primarily in the field of relativity and electrodynamics, with ramifications into quantum theory, optics, and allied fields. One of the achievements that stood at the top, or near the top, of those on which he himself placed greatest weight was his derivation of the equations of electrodynamics on the basis of a postulate having to do with

the emission of particles from charged bodies. The particles are supposed to be emitted with the velocity of light in the direction of the lines of force of each individual point charge, as observed in the system of axes in which the point charge is momentarily at rest. It is probable that Page attached no attributes of reality to the particles in question but used them as devices to formulate, through the theory of relativity, the Maxwell-Lorentz system of equations in what appeared to him to be the most elegant form.

Page's writings covered a wide range of problems and were frequently concerned with clarifying and putting into exact form electromagnetic problems that had previously been presented in erroneous guise or in a manner lacking logical continuity.

In the era intervening between the great giants of the last century—Maxwell, Kelvin, Helmholtz—and the present epoch in which theoretical physics has assumed such strange forms, forms quite at variance with the methods of thinking of those who created classical physics, we find a group of theoretical physicists, of whom Leigh Page was an outstanding representative. This group, trained in the philosophy of Victorian physics, was, in its younger days, prepared to strain the bonds of classicism within reasonable limits, with minds attuned to a comprehension of the newer thoughts of the quantum theory, just dawning upon the horizon, so that these physicists were masters in the new domain as, by training, they were masters in the old. In spite of these radical tendencies in their youth, they tended to become conservative with age and to view with a certain sadness the implication that the physics in which they had been brought up could not somehow or other be made to cover the whole realm of nature.

Leigh Page was particularly sensitive to the strife between the new and the old. Fully conscious of the new, he yet felt that it was his duty to trace as far as possible the potentialities of the old for covering the new domain. Much of his time during the last decade of his life was spent in pursuit of this idea, and a great volume of his work remained unpublished and uncompleted at the time of his death.

Naturally, one of the first battles to be fought was the battle against that belief so firmly asserted by the originators of the quantum theory, to the effect that no purely electromagnetic system could be in electrodynamic equilibrium. Page expended much effort and ingenuity in drawing upon the potentialities of classical theory to realize a system in stable electrodynamic equilibrium, with characteristics—in particular, angular momentum characteristics—which he hoped might give meaning to Planck's constant h . In this effort he examined the potentialities for equilibrium of spherical rotational systems and toroidal systems, generalizing the ordinary Lorentzian equations to include magnetic densities and magnetic currents but no overall magnetic charge. With the help of this material and with the electrodynamic force generalized to in-

clude $v \times E$ terms in true mathematical analogy with the $v \times H$ terms, he sought to prove the possibility of the existence of systems that would be in equilibrium in the sense that at each point of the system the total electrodynamic force would be zero. He succeeded in proving the possibility of the existence of such systems, but up to the time of his death his hope of finding the systems and of discovering in their structure a unique or, preferably, a discrete set of possibilities as regards angular momentum in which Planck's constant h would make its natural appearance was not completely realized.

It was his thought to realize radiation as a result of the perturbation of a system of this kind, a perturbation that destroyed its equilibrium. Presumably he expected to be led to various states of equilibrium for the electron with different angular momenta and different energies, so that as a result of such perturbation radiation could be emitted—again supposedly by purely classical processes in the normal process of passing from one state of equilibrium to another.

Leigh Page was a tireless worker who begrudged every interruption that took time from his researches or from the preparation of his lectures, in which he was most conscientious. In spite of this, he was a shrewd businessman. He managed his father's estate with such efficiency that over a period of years he substantially increased its value. Generally reputed to be a man of considerable means, he had the New England abhorrence of waste and lack of thrift but was most generous in large things. He had those qualities that greatly endeared him to his friends and a sense of humor that made him a delightful companion.

In the realm of recreation Page was fond of tennis, mountain climbing, and automobile touring, and he frequently took vacation trips over considerable distances both in America and abroad. His summers were spent at his residence in the White Mountains.

In 1910 Leigh Page married Mary Edith Cholmondeley Thornton at Manitou, Colorado, and thus secured a partner to whose sympathetic understanding he doubtless owed much of his success in life. Mary Page possesses the characteristic of making everyone happy around her. She is a tireless worker and always to be found with half a dozen activities on hand, every one of them concerned with lessening the burdens of others. Leigh Page is survived by his widow, three children—Thornton Leigh, Barbara Helen (now Mrs. W. C. Elmore), and Marjorie (now Mrs. Edmund Piper)—and nine grandchildren.

Page was a member of the Connecticut Academy of Arts and Sciences, a fellow of the American Physical Society, of the American Academy of Arts and Sciences, and of the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. In his death science has lost an outstanding contributor, whose feet were firmly on the ground of logical discipline. His colleagues have lost a dear friend who was a worthy gentleman of the highest type.

News and Notes

Opening of the New Psychiatric Institute of the University of Maryland

THE formal opening of the new Psychiatric Institute of the University of Maryland took place Nov. 17-19, 1952, in a series of dedication exercises in Baltimore. The first day of formal ceremonies was devoted to the dedication of the building and to the conferring of the honorary D.Sc. degree on Ralph W. Gerard, professor of neurophysiology in the Department of Psychiatry, and professor of physiology, University of Illinois; John von Neumann, research professor of mathematics, Institute for Advanced Study, Princeton; and Stanley Cobb, Bullard professor of neuropathology, Harvard Medical School. At the dedication dinner, Alan Gregg, vice president of the Rockefeller Foundation, gave an address on "Information, Power, and Responsibility."

The second and third days of the ceremonies were devoted to scientific meetings at which the subject of "Mechanisms of Change in Behavior" was discussed. The topic of the second day was "Factors Influencing Behavior," with Ralph W. Gerard serving as chairman. Speakers included Holger Hyden, professor and director, Histological Institute, Faculty of Medicine, Gothenburg, Sweden; J. H. Quastel, director, Research Institute, Montreal General Hospital, Canada; Raphael Lorente de No, Rockefeller Institute for Medical Research, New York; O. Hobart Mowrer, research professor of psychology, University of Illinois; and Stanley Cobb. At an evening session, Margaret Mead, associate curator of ethnology, American Museum of Natural History, gave a public lecture entitled "An Anthropologist Looks at Contemporary Behavior."

The topic on the third morning was "Medical Education and Change in Behavior." Under the chairmanship of Alan Gregg, the following speakers participated: John R. Reid, professor of philosophy at Stanford University and visiting professor of psychiatry, University of Maryland; Philipp G. Frank, president, Institute for the Unity of Science, Boston, and lecturer on mathematics and physics, Harvard University; Thomas Hale Ham, professor of medicine, School of Medicine, Western Reserve University; George Saslow, associate professor of psychiatry, School of Medicine, Washington University, St. Louis; and Jacob E. Finesinger, professor of psychiatry, School of Medicine, University of Maryland. The ceremonies closed on the third afternoon with a discussion of "Psychotherapy and Change in Behavior," under the chairmanship of John C. Whitehorn, Henry Phipps professor of psychiatry and director of the Department of Psychiatry, School of Medicine, Johns Hopkins University. Participants included Talcott Parsons, professor of sociology, Harvard; Anatol Rapoport, assistant professor of mathe-

matical biology, University of Chicago; Robert Waelder, Philadelphia Institute of Psychoanalysis; Jerome Frank, Johns Hopkins University; Carl R. Rogers, professor of psychology, University of Chicago; and Maurice H. Greenhill, associate professor of psychiatry, School of Medicine, University of Maryland.

The new \$3,000,000 Psychiatric Institute provides 102 beds for in-patient care, with three floors of the building devoted to an out-patient clinic, research laboratories, and teaching facilities. The building is designed to emphasize psychiatric teaching, integration with other medical disciplines, and research in medical education and the behavioral sciences, as well as to provide adequately for clinical services. The institute is under the direction of Jacob E. Finesinger.

JACOB E. FINESINGER

School of Medicine, University of Maryland

Scientists in the News

Samuel E. Q. Ashley, of Lenox, Mass., chemical supervisor in the General Electric Transformer and Allied Products Laboratory, Pittsfield, has been appointed manager of the G. E. Major Appliance Division Laboratory, Louisville, Ky., where he assumed his duties Mar. 16.

P. M. S. Blackett, Langworthy professor of physics, University of Manchester, has been appointed to the university chair of physics tenable at the Imperial College of Science and Technology, London.

William W. Cort will retire June 30 as professor of parasitology, School of Hygiene and Public Health, Johns Hopkins University, and will be succeeded by Frederick B. Bang, associate professor, Department of Medicine. Dr. Cort will be research professor in the School of Public Health, University of North Carolina, beginning in September. He will continue his summer program as research collaborator at the University of Michigan Biological Station.

Harold S. Feldman has been appointed director of medical research for Maltbie Laboratories, Newark, N. J. He has been resident in medicine at the U. S. Public Health Service Hospital, Staten Island, since 1950.

Henry B. Fry, formerly deputy manager of the New York Operations Office, Atomic Energy Commission, was appointed manager, effective Mar. 1, to succeed W. E. Kelley, who has resigned. Mr. Fry has been with the AEC since May 1947.

Andre J. Guinier, of the National Conservatory of Paris, and visiting lecturer in applied science at Harvard this spring, delivered the 1953 Robert S. Wil-

hams Lectures in the Department of Metallurgy, MIT, Mar. 10-12. Dr. Guinier spoke on "Precipitation Phenomena in Supersaturated Alloys," and "Recent Progress in X-ray Crystallography."

Clifford W. Hesseltine has joined the Northern Regional Research Laboratory, Peoria, to be in charge of the Fermentation Division's Culture Collection Section. Dr. Hesseltine was previously in charge of the microorganism collection at the Lederle Laboratories, Pearl River, N. Y., and will succeed **Kenneth B. Raper**, now professor of bacteriology at the University of Wisconsin.

L. O. Kunkel, of the Rockefeller Institute for Medical Research, is visiting professor in the Department of Plant Pathology at Cornell University during March. Dr. Kunkel is giving a series of lectures and demonstrations on plant virus diseases, and will be available for informal discussions and consultation on plant virology.

Thomas J. McNaughtan, formerly assistant director of research at the Leroy, N. Y., laboratories of Durez Plastics & Chemicals, Inc., has joined the Borden Company's Chemical Division as development manager at its newly completed laboratory in Philadelphia.

Jean Piaget, experimental psychologist of the Sorbonne and the universities of Geneva and Lausanne, will visit this country Mar. 22-Apr. 5, for a series of conferences at American universities.

Edward Steidle, dean of the School of Mineral Industries at Pennsylvania State College since 1928, will retire with emeritus rank on June 30. **Elbert F. Osborn**, associate dean, will succeed Dr. Steidle.

Howard O. Tricbold has been appointed head of the Department of Agricultural and Biological Chemistry at Pennsylvania State College. He has been associated with the department since 1926, and has served as acting head since the retirement of **R. Adams Dutcher** in 1951.

Orville Frank Tuttle has been named professor of geochemistry and head of the Department of Earth Sciences, Pennsylvania State College, effective July 1. Dr. Tuttle has served since 1946 as a petrologist at the Geophysical Laboratory, Carnegie Institution of Washington.

Robert van den Bosch, entomologist with the Biological Control Department, University of California Citrus Experiment Station, Riverside, will spend four months searching the cultivated areas of North Africa for parasites to control black scale, a citrus pest.

John Walton, of the Botany Department, University of Glasgow, spoke at a University of California joint seminar of the departments of paleontology and botany, on methods of preparation of Carboniferous plants and their interpretation.

Education

The Department of Education of the University of Bristol, England, and the **H. H. Wills Physical Laboratory**, in cooperation with the Institute of Physics, will conduct a short summer school followed by a conference on "The Theory of the Plastic Deformation of Metals, with Special Reference to Creep and to Fatigue," July 13-16. Lecturers will include **N. F. Mott**, **A. J. Forty**, and **F. C. Frank**. There will be a small fee for the school, but none for the conference. Full particulars and application forms, to be returned before May 31, may be obtained from the university, or from the secretary of the institute, 47 Belgrave Sq., London, S. W. 1.

The Division of Social Sciences of **Howard University**, in cooperation with the Howard chapter of the **American Association of University Professors**, held a conference on "Academic Freedom in the United States," Mar. 11-14. In addition to Howard faculty members, **Sidney Hook**, **Arthur O. Lovejoy**, **Elmer Davis**, **Verner Clapp**, **Alan Barth**, **Ralph Himstead**, **V. T. Thayer**, and others took part.

The **Medical College of Georgia**, Augusta, will offer a training course for cardiovascular investigators in the departments of physiology and pharmacology, beginning July 1. **W. F. Hamilton** and **R. P. Ahlquist** will be in charge of the 12-month program, which is supported by the National Heart Institute. For information or application forms for research traineeships, write either Dr. Hamilton or Dr. Ahlquist.

The **University of Rhode Island** is accepting applications for admission in September to the third class in the graduate curriculum in biological oceanography and marine fisheries biology. The two-year program, leading to the M.S. in biological oceanography, is sponsored by the university and the **Woods Hole Oceanographic Institution**, and instruction is offered by members of both staffs. The first academic year and the following summer are spent on the campus and at the **Narragansett Marine Laboratory**; original research occupies the second year, which may be spent at the laboratory or, by special arrangement, at other institutions. **Charles J. Fish** is in general charge. Applications should be addressed to the university's director of graduate studies. Candidates for the curriculum may also apply for graduate fellowships, of which a few at \$1200 per year are available.

The **University of Wisconsin** has promoted **Theodore C. Erickson** from associate to full professor in the Medical School and has appointed **John T. Mendenhall** associate professor of surgery. Dr. Mendenhall is chief of surgery at the VA Hospital in Madison.

Yale University dedicated the \$9,000,000 Memorial Unit of the Grace-New Haven Community Hospital on Feb. 5. The unit increases the capacity of the hospital to 805 beds. Yale has recently received from the Commonwealth Fund of New York a grant of \$2,500,-

000 for construction of a residence hall for medical students, to be built adjacent to the Sterling Hall of Medicine and the hospital.

Grants and Fellowships

The following AAAS Research Grants have been awarded: British Columbia Academy of Science, for C. A. Swanson, D. A. Trumpler, and C. Forese, University of British Columbia; Florida Academy of Science, for William J. Hargis, Jr., Florida State University; Louisiana Academy of Science, for Percy Viosca, of New Orleans; Minnesota Academy of Science, for James A. Jones, of Macalester College, and Richard L. Pierce, University of Minnesota; Oklahoma Academy of Science, for Gordon Schilz, Southeastern State College, and Edwin F. Alder, University of Oklahoma; Texas Academy of Science, for C. A. McLeod, Sam Houston State Teachers College; and to the Virginia Academy of Science, for J. J. Murray, of Lexington; J. T. Baldwin, Jr., College of William and Mary; Marcellus Stow, Washington and Lee University; and K. E. Hyland, Jr., of Christchurch School—all for studies of the Dismal Swamp.

More than 3000 applications were received by the National Science Foundation for graduate fellowships for the academic year 1953-54, an increase of about 11 per cent over the number received last year. From this group about 600 fellows will be selected. Chemistry (769), physics and astronomy (709), mathematics (349), and engineering (330) were the fields in which most applicants were interested, with conservation and wildlife (11) at the bottom of the list. Stipends range from \$1400 to \$3400, with additional allowances for dependents, tuition, and other normal expenses.

The New York Zoological Society has renewed for 1953 its "Point Four" program of aid to biological research in Europe. In 1952 the society made grants for research to individuals and institutions in Austria, Belgium, Denmark, England, France, Germany, Holland, Italy, Spain, Sweden, Switzerland, and Turkey. Again in 1953 funds will be made available to research departments or individual investigators in universities, natural history museums, zoological parks, aquariums, and nonprofit biological laboratories. The use of funds is limited to the purchase of specific items of research equipment, books, and technical journals, and the costs involved in providing experimental material. It is not intended to provide assistance to personnel of medical institutions, commercial laboratories, government-sponsored programs or any program concerned primarily with applied or economic biology. However, individuals or groups in such organizations are eligible in respect to basic studies of their own carried on simultaneously and separately. Applications for grants should be addressed to Ross F. Nigrelli, chairman, New York Zoological Society European Research Fund, Zoological Park, New York 60, USA.

In the Laboratories

Chemstrand Corporation has added the following members to its staff at Decatur: George E. Ham, Clarence I. Johnson, Rutherford B. Thompson, Jr., Edward H. Sundbeck, and Peter P. Hermes. At the nylon manufacturing and processing facilities now under construction at Pensacola, the following were appointed to supervisory positions: Robert Johnson, Walter T. Cline, Jr., Walter E. Eisele, William H. Matthews, Eugene Negro, Richard T. Phelps, Jr., Norman C. Sidebotham, Shelby L. Walters, and Andrew W. Williams.

Grinnell College dedicated its Hall of Science Mar. 13-14, with an address by Laurence M. Gould, president of Carleton College, on "The Role of the Sciences in Humane Learning;" a symposium on "The Future of Science," with R. W. Gerard, W. Albert Noyes, Jr., and Oliver E. Buckley, as speakers; an address by Watson Davis, on "The Discovery of Science Talent;" a program for teachers of science on the "Integration of Science Teaching between High School and College;" and a special showing of scientific movies for high school science students.

New York University, the University of Alaska, and the Office of Naval Research are joint sponsors of an expedition to establish a cosmic ray research station, if feasible, on Mount Wrangell. Serge A. Korff, of the Department of Physics, NYU, and Terris Moore, president of the University of Alaska, are organizing the group. Dr. Moore has resigned his post as university president, effective July 1, to devote his full time to the cosmic ray project. He will, however, retain his position as professor on the university staff.

In the Snow, Ice, and Permafrost Research Establishment (SIPRE), in Wilmette, Ill., Chicago suburb, the Army Corps of Engineers is collecting data on the properties and formation of the three materials from which the project gets its name. Current emphasis is on basic research, under the direction of Henri Bader, as chief scientist and head of the snow and ice research branch. A. Lincoln Washburn, former executive director of the Arctic Institute of North America, is in charge of SIPRE.

Meetings and Elections

A group of approximately 100 child psychiatrists has organized the American Academy of Child Psychiatry. At a meeting held in Cleveland in February, the following officers were elected: president, George E. Gardner, Boston; president-elect, Fred Allen, Philadelphia; secretary, Frank J. Curran, Charlottesville, Va.; treasurer, Mabel Ross, New York. Membership is limited to physicians who are members of the American Psychiatric Association and who have had at least two years' training in a clinic deemed adequate to give the proper training. A member must have had at least five years' experience in child psychiatry after completion of his training period, and in addition he

must demonstrate that his chief professional interest and activity are in that field. Leo Kanner, of Baltimore, has been appointed chairman of a program committee to plan for a scientific session in Los Angeles, May 4.

Case Institute of Technology will hold a convocation Apr. 10-11 to discuss "The Atomic Age—Challenge to Free Men," as the first in a series of celebrations extending over three years and marking its diamond jubilee. The convocation will meet in six sessions. Grove Patterson, editor-in-chief of the Toledo *Blade*, Zay Jeffries, E. V. Murphree, Farrington Daniels, and H. A. Winne will participate in the first panel on "Lifting the Burden from the Backs of Men." In the second, dealing with "Controlling the World's Energy for Man's Tasks," Vannevar Bush, Claude E. Shannon, Earnest A. Hooten, and Louis N. Ridenour will speak. The third panel will consider "Effective Utilization of Controlled Energy by Organized Society," under the chairmanship of Willard T. Chevalier. Charles Goodeve, director of the British Iron and Steel Research Association, Gwilym Price, and Karl T. Compton will speak. The final panel discussion will present Gilbert Highet, Rabbi Abba Hillel Silver, Detlev W. Bronk, and F. S. C. Northrop in "Attaining Man's Hopes in the Atomic Age." Complete evening programs are still to be announced.

The **International Congress for Microbiology**, to be held in Rome, Sept. 6-12, will add a subsection on bacterial taxonomy to the sections listed in the preliminary program. Those who wish to read papers before the subsection should send titles and abstracts (two copies) either to S. T. Cowan, National Collection of Type Cultures, Central Public Health Laboratory, Colindale Ave., London, N. W. 9, or to the secretary-general of the congress, Istituto di Igiene, "G. Sanarelli," Città Universitaria, Rome, before Apr. 30.

Resources for the Future, Inc., has called a national meeting of a Council of Sponsors, Apr. 20-22, to review plans for the forthcoming Midcentury Conference on Resources for the Future. The organization, established last November, has received a grant of \$150,000 from the Ford Foundation to prepare for and conduct the conference. Horace M. Albright, U. S. Potash Company, is president of the conference. Members of the Board of Directors are Edward J. Condon, Sears, Roebuck & Co.; Reuben C. Gustavson, University of Nebraska; E. B. MacNaughton, former president of Reed College; Leslie A. Miller, former governor of Wyoming; Fairfield Osborn, Conservation Foundation; William S. Paley, Columbia Broadcasting System; Beardsley Ruml; Stanley Ruttenberg, CIO; and M. L. Wilson, former director of extension, USDA. Norvell W. Page is conference director, with offices in the Cafritz Bldg., Washington, D. C.

A **Symposium on Microwave Optics** will be held at McGill University, June 22-24, under the sponsorship of Commission 6 of the Canadian National Committee

and Commission 6A of the U.S.A. National Committee of the International Scientific Radio Union. The symposium will mark the opening of the Eaton Electronics Research Laboratory. Papers on the following topics are invited: diffraction and scattering, measurement techniques for diffraction and scattering, physical optics applied to microwave systems, operational methods in optics, applications of information theory to microwave optics, geometrical optics and applications to radio problems, and artificial dielectrics. Abstracts, of not more than 200 words, should be sent by Apr. 14 to G. A. Wootton, Eaton Laboratory, McGill University, Montreal, and summaries of 1500 words by May 1.

Miscellaneous

Imperial Chemical Industries Limited, publishers of *Endeavour*, will award five prizes at the meeting of the British Association for the Advancement of Science, for essays submitted on any of the following subjects: radio astronomy, color and chemistry, biology in world affairs, science and safety in transport, science and art, scientific contributions to medicine, scientific societies and their role, power and civilization. The competition is restricted to those whose 25th birthday falls on or after the June 1 deadline for receipt of entries. Successful competitors will be invited to attend the BAAS Liverpool meeting, Sept. 2-9, with expenses within the United Kingdom paid. For further information address the assistant secretary, BAAS, Burlington House, Piccadilly, London, W. 1.

Johnson Reprint Corporation, 125 E. 23rd St., New York 10, has available reprinted volumes of the *Annual Review of Biochemistry*, Vols. 1-5 (1932-36), Vols. 8-11 (1939-42), and Vols. 14-15 (1945-46), which had been out of print.

Mercer Biological Research, Inc., a nonprofit corporation, was chartered Jan. 7 under the laws of the State of New Jersey. It was created to constitute a liaison between professional biologists and organizations or individuals requiring consultant service. Inquiries should be addressed to the corporation, Box 363, Princeton, N. J.

Pollen of the species of conifers of the eastern U. S. and southeastern Canada is needed for size-frequency studies in the preparation of a *Pollen Atlas* intended to facilitate the identification of fossil materials in pollen analytical studies of late- and postglacial sediments. In instances where the identification of species is critical, it would be helpful if a leafy twig and a female cone were included with the mature male cones. Geographic location needs to be known. Pollen is sought especially of species of *Abies*, *Picea*, and *Pinus* from the East. Material of *Pinus* from the Northwest would also be welcome. Address all communications to Stanley A. Cain, School of Natural Resources, University of Michigan, Ann Arbor.

Technical Papers

Experimental Production of Arthritis¹ in Rats by Hypophyseal Growth Hormone²

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The temporary reversal of the course of rheumatoid arthritis and other related conditions following treatment with certain adrenal steroids or adrenocorticotrophic hormone (ACTH) has suggested that the adrenal gland plays only a secondary etiological role, and that the effects of such treatment are of importance only in diminishing the activity of an as yet unknown factor or agent acting at the cellular or tissue level. The adrenal steroids seem, at least in part, to protect tissues and cells from the effects of such a factor.

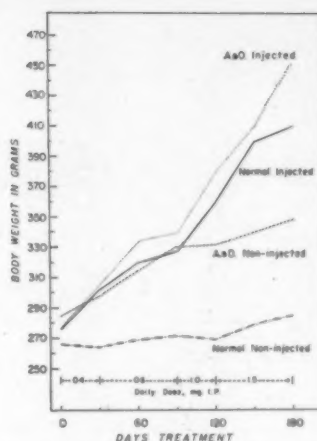
Certain lines of evidence have repeatedly suggested that endocrine imbalances may result in the production of, or be associated with, various types of chronic arthritis (1-3). Exact experimental demonstration of such relationships has not been attained, principally for lack of definition of the experimental conditions required for the production of arthropathies after treatment with purified hypophyseal hormones. Silberberg (4) has, however, reported the production of an "acromegalic arthropathy" in the guinea pig, induced after short-term injection of extract of anterior pituitaries of cattle, and Selye (3) has likewise noted the production of an arthritis of rheumatoid type in otherwise intact rats after treatment with lyophilized anterior pituitaries. On the other hand, adrenalectomy has been shown to predispose to spontaneous (5) or desoxycoorticosterone-induced arthritis (2) in rats.

The above and other clinical observations have suggested that pituitary hormones are of importance in the production of experimental arthritis. A working hypothesis that may be formulated from these observations holds that some hormonal factor(s) in the anterior pituitary can be antagonized directly or indirectly by certain adrenal steroid hormones, and that temporary alleviation of signs and symptoms of various connective tissue and joint lesions by such adrenal steroids may represent, at least in part, either a decrease in hormonal production by the pituitary and/or an antagonism of hormones at the peripheral tissue levels.

The experiments herein described present preliminary evidence that points to a significant role of pituitary growth hormone in the production of chronic

¹ Since the arthritis described here is not necessarily rheumatoid and yet presents certain of its characteristics, the term "chronic arthritis" is employed with reservations.

² This investigation was supported in part by a grant from the Albert and Mary Lasker Foundation.



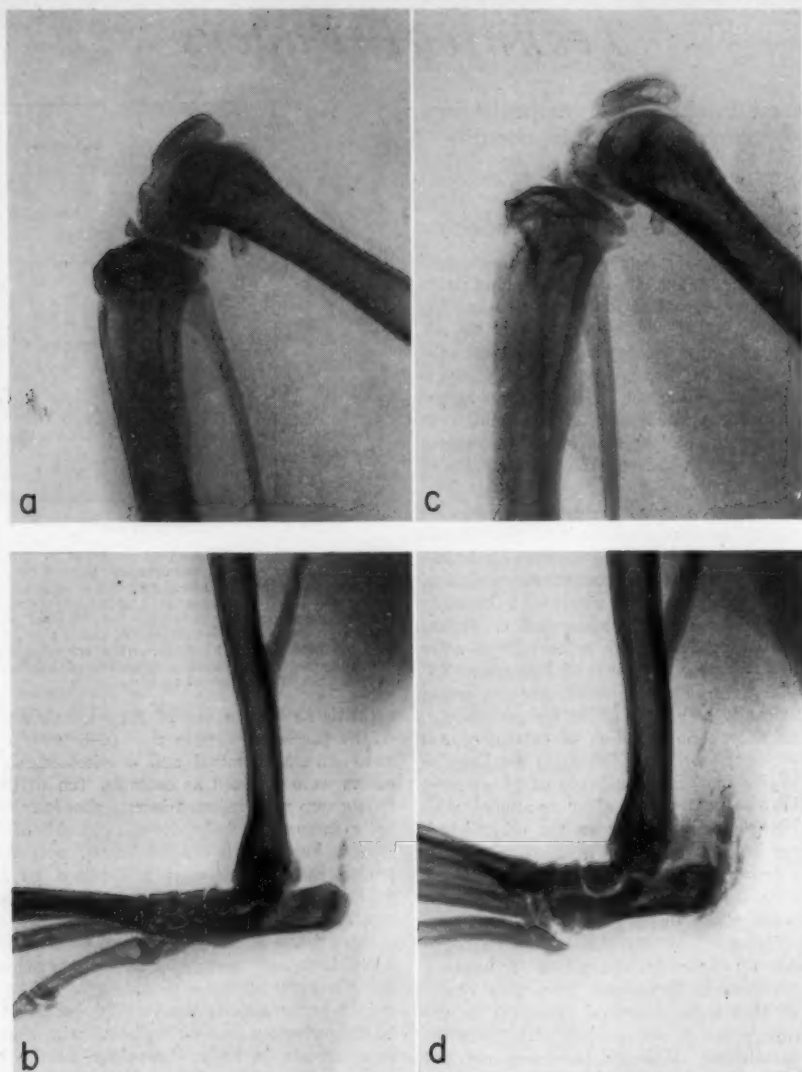


FIG. 2. Radiographic demonstration of articular and extra-articular changes in knee and ankle regions in growth hormone-treated, adrenalectomized-ovariectomized rats (c and d) as compared with normal control (a and b).

muscle tone was diminished, the animals appeared irritable, and evidence of knee and ankle joint tenderness, along with transient episodes of joint-swelling, became apparent. Five of the adrenalectomized ovariectomized animals treated with growth hormone and 3 of the untreated operated group succumbed to intercurrent infections or exhibited signs and symptoms resembling delayed terminal adrenal insufficiency. During the course of the experiment, two of the growth hormone-treated, adrenalectomized-ovariecto-

mized rats, in poor condition, were treated with hydrocortisone for one week, with apparent symptomatic relief and diminution of joint-swelling and tenderness.

Radiographic study of all animals at the end of the treatment period disclosed evidences of joint disturbances, particularly at the knee, characterized by irregularities and erosions of condylar margins, localized osteoporotic areas in the condyles, with evidence of lipping and calcification at joint margins (Fig. 2).

These changes were present in varying degrees in all the growth hormone-treated, adrenalectomized-ovariectomized rats, in but one of the growth hormone-treated normal controls, and in none of the untreated controls. In addition, both groups of growth hormone-treated animals exhibited distinct extra-articular calcifications at the ankle joint and in the neighborhood of the Achilles tendon and in adjoining fascial planes.

The importance of these observations is provisionally thought to be related to the well-known antagonism existing between the pituitary growth hormone and certain adrenal steroids (as well as ACTH acting indirectly) on the various manifestations of growth. It should be noted that the demonstrated arthropathic effects of purified pituitary growth hormone are not mediated by the adrenal gland (or gonads).

If the above observations are confirmed, the groundwork can be laid for the verification of a hypothesis which holds (1) that the pituitary growth hormone may be of direct etiological importance in the chronic arthritides and in related conditions; and (2) that the ameliorative antiarthritic effects of ACTH, cortisone, and hydrocortisone may be considered to represent either suppression of pituitary growth hormone secretion, or antagonism to growth hormone (or to its local effects) at the tissue level, or both. It should be noted, however, that the experimental evidence described herein does not preclude the possible existence of sensitization to growth hormone (endogenous or exogenous) or of production of hypersensitivity to other allergenic factors or agents.

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The Relation of Bacteriophage to the Change of *Corynebacterium diphtheriae* from Avirulence to Virulence¹

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Freeman (1, 2) has reported that exposure of an avirulent strain of *Corynebacterium diphtheriae* to a specific bacteriophage results in the production of virulent *C. diphtheriae*.² In addition he has observed that all virulent strains derived in this manner exhibit lysogenicity when tested against the parent

¹ Supported in part by State of Washington funds for medical and biological research.

² The terms "avirulent" and "virulent" are used synonymously with "nontoxicogenic" and "toxicogenic."

avirulent strain. These results, confirmed in part by Parsons and Frobisher (3), have been fully confirmed in our own laboratory (4). Two possible explanations for the origin of these virulent organisms have been advanced (1, 2). They are (a) that virulent mutants develop in the avirulent culture and are subsequently selected for by bacteriophage action, and (b) that infection and the establishment of the lysogenic state alter the metabolism of the infected cells, with resultant production of toxin. The present report provides evidence compatible with the hypothesis linking lysogenicity and virulence and inconsistent with the hypothesis of mutation and selection.

Strain 444 of avirulent *C. diphtheriae*³ as designated by Freeman (1) was used in the work to be described. This parent avirulent strain and the derived virulent strains will be referred to as 444A and 444V, respectively. The bacteriophage employed throughout has been designated 444V/A. It was isolated from strain 444V, produced by exposing 444A to bacteriophage B, described by Freeman (1), and was propagated on 444A. In all probability it is identical with bacteriophage B. Investigation of this phage-host system (4) indicates that, although it is strongly lytic, lysogenic cells are produced with extraordinary facility. It is similar in this respect to systems described by Burnet and Lush (5) for a *Staphylococcus* and Boyd (6) for *Salmonella typhimurium*.

The correlation between virulence and lysogenicity observed by Freeman (1) in the derived strain 444V, and repeatedly confirmed in the course of the present work, is highly suggestive of a causal relationship between the two changes in character. Nevertheless, it can be argued that a virulent mutant arising independently of bacteriophage action might simultaneously become receptive to a state of lysogenicity. If this occurred the establishment of the lysogenic state would be a result of the change to virulence rather than its cause. Thus, other evidence is required before any significance can be attached to this correlation.

Strong evidence against the mutation-selection hypothesis was obtained in the following manner. Samples were removed periodically from a mixture of *C. diphtheriae* 444A and bacteriophage 444V/A. Each sample was plated for total bacterial count and analyzed for the relative numbers of virulent and avirulent cells present. A differential medium exploiting the visibility of toxin-antitoxin precipitates in an *in vitro* system was used to distinguish between virulent and avirulent colonies. Plate differentiation was confirmed by guinea pig intracutaneous tests and *in vitro* virulence tests (7). Lysogenicity was demonstrated using parent strain 444A as the indicator strain. Because of the clumping exhibited in the normal growth of *C. diphtheriae* the counts obtained represent "clump" counts. The data are presented in Table 1.

³ Kindly supplied by V. J. Freeman.

TABLE 1
NUMBERS OF VIRULENT *C. diphtheriae* PRESENT ON
INCUBATING AVIRULENT STRAIN 444A WITH
BACTERIOPHAGE 444V/A

| Expt. no. | Time elapsed (hr) | Bacteria | |
|--------------|-------------------------|-------------------|----------------------|
| | | Total no./ml | No. viru- lent/ml |
| 1 | 0 | 2.4×10^3 | < 1* |
| | 3 $\frac{3}{4}$ | 1.4×10^4 | 640 |
| | 5 $\frac{1}{4}$ | 5.0×10^4 | 23,000 |
| 2 | 0 | 1.9×10^3 | < 1* |
| | 3 $\frac{1}{2}$ | 9.6×10^4 | 2,000 |
| | 5 | 6.4×10^4 | 37,000 |

* None detected in the sample.

Examination of the increase in the numbers of virulent cells (Table 1) reveals some important facts. It has been determined in independent experiments that the shortest generation time of virulent strain 444V is 51 min under the conditions of the experiments. It can be calculated that in the period of 3 $\frac{3}{4}$ to 5 $\frac{1}{4}$ hr (Expt. 1) the virulent population of 640 cells/ml, irrespective of its origin, would have reached a density of 3300 cells/ml had it multiplied at the maximum rate. The determined population of 23,000 virulent cells/ml is far in excess of this. Similarly during the 3 $\frac{1}{2}$ -5-hr period of Expt. 2 the population density would have increased from 2000 to 6800 virulent cells/ml had multiplication occurred at the optimal rate. Again the determined population of 37,000 cells/ml is far in excess of this figure. Thus, in both instances many more virulent cells were present at the end of the experimental interval than could be accounted for by division alone even if multiplication had occurred at the optimal rate. It is apparent from these facts that large numbers of additional virulent cells appeared during the experimental interval. It can also be calculated that it would have required mutation to virulence during the first division of 2.7% (Expt. 1) and 9.2% (Expt. 2) of the avirulent population present at the beginning of the cited experimental intervals to achieve the virulent populations present at their termination. This far exceeds any expected rate of spontaneous mutation. Furthermore,

TABLE 2
NUMBERS OF VIRULENT COLONIES OF *C. diphtheriae*
DEVELOPING AFTER A 30-MIN CONTACT
BETWEEN AVIRULENT STRAIN 444A
AND BACTERIOPHAGE 444V/A

| Expt. no. | No. phage- infected cells deposited on the plate | No. of virulent colonies developed | Percentage cells con- verted to virulence |
|--------------|---|---|--|
| 1 | 142 | 7 | 4.9 |
| 2 | 108 | 3 | 2.8 |
| 3 | 99 | 1 | 1.0 |
| 4 | 268 | 4 | 1.5 |
| 5 | 701 | 1 | 0.1 |

the decrease in total bacterial count, resulting from continued lysis of large numbers of avirulent cells by bacteriophage, would tend to increase these theoretical mutation rate requirements.

Further evidence was obtained which fails to support the hypothesis of mutant selection by bacteriophage. In a series of experiments, strain 444A was mixed with bacteriophage 444V/A in heart infusion broth (Difco) and incubated in a 37°C water bath for 30 min. The mixture was then diluted and aliquots were spread directly on the differential medium. In all cases the concentration of bacteriophage on the plate was low enough to rule out any reasonable possibility of contact between a phage particle and a developing colony.

The data presented in Table 2 show that 0.1-4.9% of the phage-infected cells deposited on the plates developed into virulent colonies. The percentage of virulent clones produced far exceeds any anticipated mutation rate. Furthermore, controls of avirulent cells alone plated in these and in numerous experiments performed during the past year have never given evidence of a single virulent colony. Thus again, new, virulent cells were produced by exposure of avirulent cells to bacteriophage lysates and at a rate far in excess of any expected spontaneous mutation.

The induction of virulence, as evidenced above, could conceivably be due to the presence of a soluble transforming principle released during the preparation of the bacteriophage stocks. Preliminary experiments were performed in which the stock solution of bacteriophage 444V/A was treated with crystalline deoxyribonuclease (Worthington) under conditions of activity described by McCarty and Avery (8). The enzyme concentration was 200 times the maximum used by these investigators to completely destroy the activity of pneumococcal transforming factor. The enzyme-treated bacteriophage suspension retained its ability to produce virulent *C. diphtheriae* from strain 444A. This strongly indicates the absence of a soluble transforming principle of the deoxyribonucleic acid type. However, other soluble transforming agents may exist which would be unaffected by this treatment.

In summary then, the theory that virulent mutants arise in strain 444A of *C. diphtheriae* and are selected for by bacteriophage is not supported by the facts presented here. Thus it appears that the change to virulence is an induced phenomenon. The evidence presented tends to rule out transformation by a soluble principle of the DNA type. On the other hand, the striking correlation between lysogenicity and virulence makes a causal relationship between these two changes seem probable. The high concentration of deoxyribonucleic acid present in the bacterial viruses that have been studied (9), and the intimate relationship that must exist between a bacterial cell and its symbiotic phage, give strong support to the concept that bacteriophage may indeed act as a particulate transforming principle. It is proposed to retain as a working hypothesis that the establishment of the lyso-

genic state results in an altered metabolism of the avirulent cell, an alteration manifest as toxin production.

A complete report of this work will be published elsewhere.

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Technical Modifications of Radiocardiography¹

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Radiocardiography was described in 1948 by Prinzmetal *et al.* (1), and its clinical applications were presented a year later (2). In this method, a Geiger-Mueller counter with auxiliary equipment records graphically the passing of radioactive blood through the cardiac chambers. Several disadvantages found in the application of the original method led to modifications which are reported below.

Original method (1, 2). A shielded Geiger-Mueller (GM) tube is placed in front of the precordium of the sitting patient, and 0.1–0.2 mc radiosodium (Na^{24}) is injected into one of the antecubital veins. The counts are graphically recorded from right to left by means of a specially constructed ink-writing device. The curve is corrected by taking the means of counts, and the reconstructed tracing consists of two main waves (*R* and *L*) representing the passage of the isotope through the right and left ventricles, respectively. The two waves are connected by a transitional plateau. The end of the second wave is usually at a much higher level than the baseline.

Disadvantages of the method. The following disadvantages were found in preliminary experiments:

- a) Radioactive sodium has a short half-life (14.8 hr) and may not be available when necessary. Shipment from production centers to the laboratory is by air freight and is very expensive.
- b) The poor sensitivity of the GM counter originally used required a large dose of isotope for injection.
- c) The ink-writing device is not very accurate. Writing from right to left is in contrast with accepted techniques and makes the reading awkward. The actual graph consists

¹ This study was performed under the tenure of a teaching grant of the National Heart Institute, USPHS, held by A. A. Luisada.

of several irregular oscillations; the means of counts is a somewhat arbitrary and subjective procedure which lacks accuracy.

d) There is no possibility of simultaneously recording radiocardiograms and other tracings for physiological or clinical correlation.

Modifications of technique. The isotope used in our study was I^{131} in the form of diiodofluorescein;² a dose of 20 mc in 0.5–1 ml was injected. As the half-life of I^{131} is about one week, several clinical experiments were carried out with the material of each shipment.

The detector was a bismuth gamma GM tube³ contained in a directional lead shield. The tube was suspended from a vertical stand, and the opening of the shield was placed about 1 in. from the center of the precordium (Erb's point) of the supine patient. The tube was connected to a count rate meter⁴ and the outlet of the latter, ending in a telephone plug, was connected to a direct-writing electrocardiograph⁵ with 4 channels. This permitted simultaneous recording of the radiocardiogram and of any other clinical tracing. Film speed generally used was 10 mm/sec. In some experiments, however, film speeds of 25 or 50 mm/sec were used. A signal marked the time of injection.

In our experiments, an electrocardiogram and a carotid or brachial tracing, or a respiratory tracing, were recorded with the radiocardiogram. This permitted us to ascertain the number of cardiac cycles necessary for the isotope to go through the right or the left side of the heart.

Several technical difficulties were still encountered, and some of them are not yet solved. The record of the Poly-Viso, like that of most amplifier-type galvanometers, is a plot of logarithmic intensity vs. time. There is therefore no linear proportion between the height of a deflection and the amount of isotope in the GM tube field. This tends to increase the smaller deflections and, therefore, the background effects. The use of a specially built amplifier is contemplated in future experiments.

With suitable degree of amplification, the special characteristics of the amplifier-type galvanometers automatically transform the multiple and irregular discharges of the counter into slower and more regular waves. This transformation is equivalent to, but more accurate than, the arbitrary means of discharges previously drawn over the graphs. It should be kept in mind that, following a large and slow positive deflection, the graph sometimes presents a negative deflection. This is an artifact that is due to the technical characteristics of the amplifier-type of galvanometers and should be disregarded.

² The isotope was obtained from the Abbott Laboratories, North Chicago, Ill., on allocation from the U. S. Atomic Energy Commission.

³ The tube was Mark 1, model 13, of Radiation Counter Laboratories.

⁴ The meter was No. 1615, supplied by the Nuclear Instrument and Chemical Co., to whom we are indebted for their cooperation.

⁵ The electrocardiograph used was a Sanborn Poly-Viso.

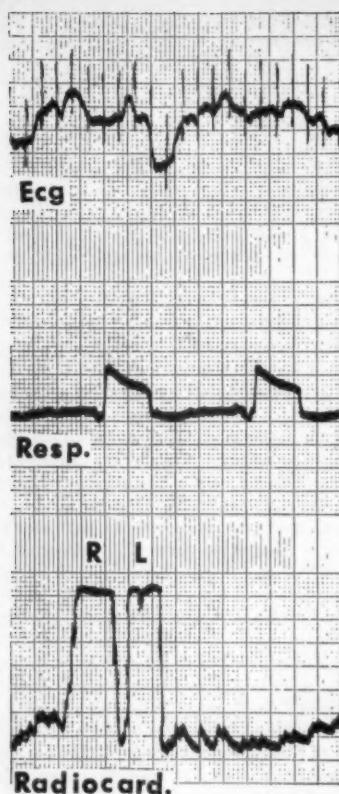


FIG. 1. Radiocardiogram of a normal dog. *R* and *L* indicate passing of the isotope through the right and left ventricles.

In a first series of experiments, 6 anesthetized dogs were studied. Later, 24 normal human subjects between 22 and 60 years of age were studied. Both in animals and in humans, the injection of the isotope is followed within 2-6 sec by a large monophasic wave lasting 1-4 sec, which may be preceded by a smaller one. Following an interval of 1-3 sec, during which the tracing may return to the baseline, a second monophasic wave occurs; this wave lasts 2.5-4 sec and is often preceded by a smaller wave (Fig. 1). It is likely that the two large monophasic waves correspond to waves *R* and *L* described by Prinzmetal and co-workers (1, 2) and are due to the passing of the isotope through the right and left ventricles. It is too early to decide whether the smaller waves preceding *R* and *L* are due to passing of the isotope within the respective atria. This possibility, however, should be considered. Both the *R* and the *L* wave frequently include from two to four smaller, rounded waves. In normal subjects, from two to four ventricular contractions occur during the passage of the isotope through each ventricular chamber.

Sometimes, after the end of the second large wave (*L*), more waves are visible. They frequently occur by couples which resemble the *R-L* couple originally observed. They have either the same or a greater height than the original couple and may be observed for several minutes. They might be explained by the recurrent circulation of the isotope through the right and left ventricles after returning from several possible routes. The shortest is the coronary circulation; the longest, the splanchnic circulation or that of the lower limbs. Theoretically, the mixing of the isotope with circulating blood should rapidly attenuate these waves. Therefore, the interpretation is still tentative.

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The Culture in the Developing Chicken Embryo of a Filtrable Agent from *Verruca vulgaris*

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Although there is abundant evidence (1-7) that the causative agent of the common wart is filtrable, there are only two reports of its having been grown in tissue other than human. Ullman (5) reported having produced a vaginal papilloma in a bitch which was inoculated with a human laryngeal papilloma, and Rhodes (8) has mentioned, without details, the successful transfer of human wart material to a monkey's prepuc. Felsher (9) reported failure to cultivate this agent in chick embryos.

A total of 17 warts developed on the author's right hand during a period of at least two years. The primary wart was removed by curettage and electrocautery on July 10, 1951, by a dermatologist.² On July 12, the wart was ground with sterile sand in a mortar until the whole was reduced to a fine powder. This was suspended in 3-4 ml of nutrient broth and frozen. Aerobic agar culture remained sterile. On July 13, the sample was thawed, resuspended, and centrifuged. One ml of the supernate was added to 10,000 u of penicillin and 10 mg of dihydrostreptomycin, each contained in 0.1 ml of .85% NaCl solution. The mixture was then inoculated on the chorioallantoic membrane (CAM) of each of 5 chick embryos 10 days old in a dose of 0.2 ml/egg by the routine technique employed in this laboratory (10). The original nontreated suspension was inoculated on the CAM of each of 2 other eggs in a somewhat larger dose.

¹ Paper of the Journal Series.

² O. J. Sokoloff, 60 Paterson St., New Brunswick, N. J.

Two of the 5 eggs receiving antibiotic-treated inocula were examined on the fourth postinoculation day. No lesions were observed. On the seventh day, the remaining 3 were examined. Two had barely perceptible lesions at the inoculation site, and the pole of the third had the rough appearance of sandpaper with definite but small cystlike proliferations at the inoculation sites. One of the 2 embryos inoculated with nontreated suspension had an edematous CAM, particularly at the pole, and small but definite raised lesions at each inoculation site. The last embryo, which received more inoculum than any of the preceding, had several hard, whitish "pearls," which were raised above the surface of the CAM about $\frac{1}{8}$ in. Aerobic agar cultures remained sterile. Subsequent passages have shown that the agent grows well on the CAM of 10-day-old chick embryos, routinely producing dense white to greenish pearls varying in size but usually between $\frac{1}{16}$ and $\frac{3}{16}$ in. in diameter. Occasionally, many much smaller secondary lesions are present on the CAM. In a few embryos there has been evidence suggesting that destruction of blood vessels has occurred, thus permitting hemorrhage. When the individual lesions are close enough to coalesce, a yellowish substance resembling necrosed tissue has been observed between the CAM and the inner shell membrane.

To demonstrate the filtrability of the agent provoking these lesions, a Boerner filtrate of a ground suspension of first-passage membrane and a Boerner and a Berkefeld "V" filtrate of a second-passage membrane were prepared and inoculated on the CAM of 10-day-old embryos. Neither Boerner filtrate produced lesions, but the Berkefeld filtrate caused lesions which could not be distinguished from nonfiltered material. Aerobic agar cultures of the filtrates and of all eggs inoculated with them or with nonfiltered material remained sterile. Since the Boerner filter utilizes a Seitz-type asbestos pad, these results were not unexpected.

Because of the character of the lesions produced and because of the filtrability of the agent causing them, it seems probable that a virus has been cultured. More detailed information on this and other aspects of the problem are to be considered in a future report.

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A Metabolism Unit Designed for Radioisotope Balance Studies with Dogs¹

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The dog is widely used in nutritional and physiological experimentation. Problems raised by the use of radioactive materials in such studies have necessitated the redesign of cages for quantitative collection of excreta. For the most part, the cages now employed are based on that introduced by Gies (1) or Bliss (2) and consist of square or rectangular units with mesh wire bottoms upon which the animal stands over a metal urine funnel. The feces are retained by the wire floor, and the urine passes through the mesh and is directed by the funnel to a collecting vessel beneath. Details of the basic requirements that must be met by a satisfactory unit for isotope studies and the shortcomings of the conventional type of animal cage have been previously discussed (3). The need for minimizing contamination of the surrounding area and the animal itself, as well as the importance of quantitative separate collection of excreta, with a minimum of smearing on the restraining surfaces, has been emphasized (4).

Taking these requirements into consideration, a metabolism cage has been designed for balance studies with dogs that fulfills the above conditions and effects the satisfactory quantitative separate collection of urine and feces eliminated by either sex. This has

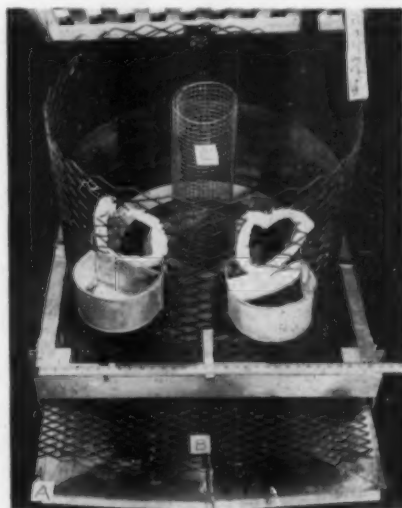


FIG. 1. Metabolism unit designed for quantitative separate collection of excreta from dogs of either sex (note circular false floor separator in position).

¹Published with the approval of the director of the University of Tennessee Agricultural Experiment Station.

been accomplished by the unique arrangement of a circular false floor that comfortably supports the animal above the wire mesh during the experimental period, and keeps him oriented in such a way that all feces, regardless of the animal's position in the unit, pass through the circular openings and are collected below on the removable mesh floor. The false floor separator, as described, can also be used satisfactorily in the ordinary commercial dog cage where balance studies are desired.

The metabolism unit illustrated in Fig. 1 is inexpensive and of simple design, with removable parts that may be easily cleaned or conveniently discarded if and when contaminated with radioactivity. The restraining walls are constructed from a 24" width of corrugated metal² mesh rolled to form a round cage 29" in diameter; the edges are held in position by four 1 1/4" bolts. Two openings are made in the front of the cage to allow the dog free access to feed and water from commercial dog feed cups suspended outside the walls. These openings are made by cutting the side and bottom of an area 6" x 6" and pulling the attached wire outward over the containers, which prevents the animal from attempting escape. The openings are protected by sewing a strip of heavy canvas around the raw edges of the metal. Four L-shaped metal straps attached to the outside walls fit over a sturdy fitted frame made from 2" x 4" boards supporting the cage at a convenient height above the floor.

The novel feature of this unit is the false circular floor separator on which the animal stands during the experimental period (Fig. 2). It is constructed from two or more concentric 3" widths of 1/2" plywood, sawed and fitted in a circular pattern 3" apart to form a removable circular floor 24" in diameter. The plywood is secured to three 1/4" iron rods that protrude outward to hook on the inside of the cage. One of these supporting rods may be retracted to permit ready removal of the floor from the cage. A 7" opening in the center of the floor permits the insertion of a 6" roll of 1/2" mesh hardware cloth (Fig. 1 C) that rests on the removable corrugated metal floor below (Fig. 1 B) and extends the entire height of the cage. This arrangement serves to restrain the animal without discomfort in such a position that the feces always pass between the plywood boards onto the metal screen below. The urine, most of which is voided by the male directly onto the hardware cloth cylinder in the center of the cage, passes through the mesh floor onto a 32" x 32" galvanized metal funnel (Fig. 1 A), which diverts it into a carboy below. To minimize splattering and the spread of radioactivity, especially with females, a removable metal liner 17" high is inserted inside the cage and fitted under the feeder against the sides of the wire mesh walls. The cage cover is constructed from conveniently spaced 1" x 2" wooden strips and is attached to the top of the cage

²No. 9-11 gauge flattened mesh is available in 4' x 8' sheets from Wheeling Corrugating Company, Wheeling, W. Va.

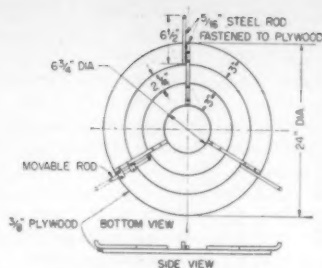


FIG. 2. Schematic diagram of the circular false floor separator for use in dog metabolism cages.

at the back with an 8" metal T-hinge; it is secured at the front by a heavy wire hook.

To facilitate cleaning and decontamination, the metal liner, false floor separator, and urine funnel are sprayed with a strippable paint³ previous to use.

This metabolism unit has wide application in studies involving not only radioisotopes, but whenever it is desirable to make quantitative separate urine and fecal collections with 7-12 kg dogs of either sex. The simplicity and economy of construction and the restraint accomplished without undue restriction of the animal's movements during the experimental period make the unit especially useful for metabolism studies with radioisotopes.

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³A strippable paint called "Cocoon" is available from Hollingshead Corp., Camden, N. J.

Fall in Minimum Night Temperature at or near Full Moon: Part II

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The atmospheric temperature fluctuations on the earth's surface have been carefully recorded for many years by numerous observers, whose investigations have elucidated most of the causes of these fluctuations. Such explanations have been founded on well-established meteorological and other phenomena, caused chiefly by the heat and light of the sun; but little attention seems to have been paid to its gravitational action, and also that of the moon, on the earth's atmosphere. The effects of the gravitational pull of both these bodies on the shape of the earth and on its tides in the waters of the seas are, of course, well established, though the exact amount of the pull, ascribed to either the sun or moon in causing any given tide, appears not to have been calcu-

lated with precision (1), owing to the continuous motion of the sun, moon, and earth.¹

The forces of the gravitational pull of both sun and moon on the sea, in causing the tides, pass through the earth's atmosphere before reaching the surface of the sea, but it cannot be supposed that these forces exert no action on the atmosphere. Such forces could not by-pass the atmosphere without affecting it, and such an effect would be to cause atmospheric tides, analogous to the water tides below them, but not identical with the latter in their modes of formation, times of occurrence, or physical results. The height of the tides is augmented by ocean currents, by winds, and by the configurations of the coasts; those of the atmosphere will be similarly modified by prevailing winds, by sudden cyclonic storms, or by the rise of large volumes of heated air from land surfaces; but there are no coasts to interfere with the atmospheric tidal waves, excepting, perhaps to a small extent, very high mountain ranges. Consequently the atmospheric tidal wave will, in the absence of such modifying influences, pass more or less smoothly around the earth, under the gravitational pull of the moon, without the time lag of the water tides, where the greater specific gravity of the water (about 815 times that of air at sea level), the horizontal component, and other forces operate; nevertheless, such an atmospheric tidal wave will be greatly modified at times by meteorological conditions, as well as by the positions of the sun and moon.

In a previous communication (2) it was demonstrated that the fall of minimum temperature near full moon was less in summer than in winter; and it is a well-known fact that the tides of the sea are lower at the summer than at the winter solstice. Since the fall of minimum temperature is a gauge of the height of the atmospheric tide, the two phenomena are in agreement with each other and must be caused by the same force.

There is a fundamental difference between the action of such a force as the moon's gravitational pull upon a solid or a liquid, on the one hand, and that upon a gas, on the other—at least near the earth's surface. In considering a cubic centimeter of earth under tidal action, it is raised *in toto*, without expansion or alteration of temperature, through a centimeter or two, and, after the tide has passed, it falls back and remains as it was originally. The same type of action occurs, under analogous conditions, in the tides of the sea; the cubic centimeter of water is raised through 10-16 cm in the Mediterranean Sea, where no disturbing factors normally arise; there is little or no alteration in its volume or temperature, and the cube of water falls back unchanged. The cubic centimeter of air, however, is not lifted up *en bloc*; it is merely expanded upwards by a slight reduction of pressure upon it; i.e., g of earth - g of moon's pull, the amount of this expansion causing a wave in the

¹ If such calculations have since been carried out, the author is unaware of them.

upper atmosphere, traveling under the moon and dependent upon various factors.

To expand a gas it must undergo either an absorption of heat under constant pressure, or a reduction of pressure under constant temperature; and since the atmosphere receives no external heat during the night, its expansion must be due only to reduction of pressure caused both by the gravitational pull of the moon when it is in or near the zenith, or by that of the sun in the nadir. But to expand a gas solely by pressure reduction necessitates an adiabatic expansion with fall of temperature, since no external work is done—i.e., the Joule-Thomson effect. The atmosphere under the full moon, therefore, is adiabatically expanded, the temperature falls and is registered by the thermometer; hence the fall of minimum night temperature near full moon (2).

There are many factors that modify this phenomenon, the chief ones being (a) the temperature, which is soon raised again, first by reabsorption of heat from the surrounding air and from the ground below, but not before the lowered temperature has had time to influence the thermometer, and, second, by a partial contraction in the initial wave owing to loss of heat on expansion; (b) the latitude of the place in which the temperature fall occurs; the value of g of the earth being slightly less and that of the moon slightly greater in low latitudes (also the air is heavier with aqueous vapor); (c) altitude: as this increases the aqueous vapor content of the air decreases; (d) meteorological conditions, such as winds, cloud, rain or snow, warm air uplift, etc.

Air in tropical regions is at a fairly high temperature even at night and is normally considerably more expanded than air in higher latitudes, as well as being more loaded with aqueous vapor; consequently, the further expansion of such warm air will not be as great under the gravitational pull of the moon as would be the case with drier air at much lower temperatures; hence adiabatic expansion will be less in volume, causing the minimum temperature fall to be less near the equator, although the pull of the moon is somewhat greater and that of the earth less.

If adiabatic expansion is the correct explanation, then there should be a fall of atmospheric pressure more or less concurrent with the fall of temperature. The sudden reduction of pressure will be greater and probably more apparent at higher altitudes. Such diminution of pressure, though only to a small extent, has been noticed in the records of two stations, both near sea level and as far apart as possible in both distance and time. Table 1 gives the minimum temperature fall, with the dates between which it occurs, and also the recorded fall of pressure with its dated periods; the two columns of dates show them to be almost synchronous and close to full moon dates.

The view that any fall of temperature near full moon is caused by absence of cloud, thus permitting the cold of higher altitudes to penetrate the lower atmosphere, is not based on exact facts. True, there

are often cloudless nights around these dates, but by no means always. In North Wales, during the years 1948-51, there were observed 27 lunations, out of which 18 were cloudy on nights covering the falls of minimum temperature; in 8 of these there was rain all night; in 9, gales, and in 1, snow. Again, the station at Dehra Dun, India, sent records of the years 1948-50, in which 33 lunations were noted; of the nights of minimum temperature fall, 20 were cloudy and 2 were rainy: at neither station did the temperature fall fail to take place.

cm; and by calculation, in which the minimum temperature fall is used as a gauge of the expansion, then from the gas equation

$$\frac{V}{T} = \frac{V_1}{T_1},$$

where $V=820$ ml; $T=288^\circ$ abs, $T_1=293^\circ$ abs, then $V_1=834$ ml. On subtraction $834-820=14$ ml expansion, which is close to the 13 cm given above.

If the volume 820 ml stands on unit area, 1 cm^2 , then it will be in the form of a square column (Säule)

TABLE 1

| Wellington, New Zealand, 1939 (Alt, 415 ft (126 m) 41° 16' Lat S) | | | | | | Caerwys, North Wales, 1949 (Alt, 600 ft (183 m) 53° 15' Lat N) | | | | | |
|--|-----------------|-----------------------|----------------|------------------|---------------|---|-----------------------|---------------|------------------|---------------|--|
| Month | Full moon dates | Barometric fall mm Hg | Between dates | Min temp fall F° | Between dates | Full moon dates | Barometric fall mm Hg | Between dates | Min temp fall °F | Between dates | |
| Jan. | 5 | 6 | 2-7 | 3 | 5-6 | — | — | — | — | — | |
| Feb. | 4 | 7 | 2-6 | 6 | 2-3 | — | — | — | — | — | |
| Mar. | 5 | 5 | 1-8 | 2 | 5-6 | 14 | 5 | 12-14 | 6 | 12-14 | |
| Apr. | 4 | 3 | 2-3 | 19 | 3-5 | 13 | 20 | 9-12 | 3 | 12-14 | |
| May | 3 | 18 | 2-7 | 14 | 4-5 | 12 | 17 | 12-14 | 9 | 9-11 | |
| June | 3 | 5 | 4-5 | 10 | May 30-June 3 | 10 | 6 | 5-7 | 16 | 7-9 | |
| July 1 | 1 | 22 | June 29-July 3 | 8 | 2-3 | 9 | 3 | 8-9 | 9 | 7-8 | |
| “ 2 | 31 | 7 | 27-29 | 2 | 30-31 | — | — | — | — | — | |
| Aug. | 29 | 16 | 28-30 | 10 | 27-28 | 8 | 6 | 7-8 | 5 | 5-8 | |
| Sept. | 28 | 3 | 27-29 | 7 | 27-28 | 7 | 4 | 4-5 | 13 | 4-7 | |
| Oct. | 28 | 9 | 28-30 | 11 | 26-27 | 6 | 11 | 4-9 | 7 | 3-5 | |
| Nov. | 26 | 2 | 25-26 | 11 | 23-25 | 5 | 30 | 1-6 | 11 | 5-6 | |
| Dec. | 26 | 12 | 20-27 | 13 | 25-27 | 5 | 5 | 4-6 | 9 | 1-5 | |

The expansion that is due to the gravitational pull of sun and moon on the atmosphere may be visualized by considering an ideal case. Taking the conditions prevalent at Perth, W. Australia, during the year 1950, a station situated at sea level and in $30^\circ 0'$ Lat S, where the average minimum temperature fall near full moon was 5°C and the temperature just before the fall was $15^\circ\text{C}=288^\circ$ abs, the volume of 1 g air at N.T.P.=777 ml corrected to $15^\circ\text{C}=820$ ml; this, then, is the volume of 1 g air at the temperature of the station, and this will be expanded under the gravitational pull of the moon. Although the strength of this pull is accurately known from Newton's law of gravitation, its exact value in causing a tide is unknown (1). It is, therefore, necessary to estimate the amount of expansion by indirect means—by analogy with the tide in the Mediterranean Sea, where there are few disturbing influences, which raises a unit mass of water, 1 g through 10-16 cm, as a mean, say, 13

820 cm high, which will be expanded upwards 13-1.6% to 833 cm. At 20,000 ft/(610,000 cm) altitude, at least half the ponderable atmosphere will be included. On extending the ideal column 820 cm to this height, there are 744 such columns, one above the other, and there will consequently be that number of 13 cm expansions, or a total of 9672 cm (317 ft).

Similar, though less strong, tidal waves will occur daily during all phases of the moon, exactly as with sea tides; nevertheless, they may be greatly altered by local meteorological conditions. They may give rise to snowstorms in high latitudes and also may be the cause of some of the “air pockets of low pressure” encountered by airmen.

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Comments and Communications

Night Temperatures and the Moon

HENSTOCK (SCIENCE, 116, 257 [1952]) has reported on the fall of the minimum temperature at or near the full moon. The writer made a similar study while he was a student at Colgate University in 1947. A remark by John Littlefield, treasurer of the university, to the effect that a full moon in winter was followed by a cold snap, led to an analysis of the lunar month on the basis of the variations in mean temperature.

Mean daily temperatures for the Syracuse, N. Y., area were obtained from Weather Bureau *Monthly Climatological Summaries* for the years 1931 through 1946. After subtracting the daily normal temperature (*Annual Meteorological Summary, Syracuse, N. Y.*,

TABLE 1
AVERAGE VARIATIONS OF MEAN TEMPERATURE MINUS
DAILY NORMAL TEMPERATURES FOR EACH DAY
OF THE LUNAR MONTH, SYRACUSE, N. Y.

| Day of lunar month | 1. All lunar months, Jan. 1931-Dec. 1946 (195 lunar months) | 2. Summer period, Apr. 20-Aug. 20, 1931, to 1946 (63 lunar months) | 3. Winter period, Oct. 20-Feb. 20, 1931, to 1946 (64 lunar months) |
|--------------------|---|--|--|
| (New moon) | — | — | — |
| 1 | +3.2* | +2.7* | +2.5* |
| 2 | 3.4 | 2.3 | 2.7 |
| 3 | 3.1 | 2.5 | 2.8 |
| 4 | 2.4 | 2.4 | 2.3 |
| 5 | 3.2 | 3.2 | 3.2 |
| 6 | 3.8 | 2.8 | 4.4 |
| 7 | (First quarter) 3.1 | 3.4 | 3.5 |
| 8 | 1.8 | 2.4 | 1.7 |
| 9 | 2.5 | 3.1 | 2.9 |
| 10 | 2.4 | 2.8 | 2.4 |
| 11 | 2.3 | 3.4 | 1.6 |
| 12 | 2.6 | 3.8 | 2.1 |
| 13 | 2.3 | 2.9 | 2.8 |
| 14 | 2.1 | 3.0 | 2.3 |
| 15 | (Full moon) 2.6 | 3.7 | 2.1 |
| 16 | 3.9 | 4.0 | 3.3 |
| 17 | 3.0 | 3.0 | 3.3 |
| 18 | 3.3 | 4.0 | 2.3 |
| 19 | 3.0 | 4.3 | 1.7 |
| 20 | 3.5 | 4.6 | 1.1 |
| 21 | 3.1 | 4.7 | 1.3 |
| 22 | (Last quarter) 3.1 | 4.4 | 0.8 |
| 23 | 3.2 | 3.9 | 1.3 |
| 24 | 3.0 | 3.7 | 1.5 |
| 25 | 2.3 | 3.4 | 1.3 |
| 26 | 2.4 | 2.5 | 1.6 |
| 27 | 2.3 | 2.3 | 2.6 |
| 28 | 2.9 | 1.2 | 0.7 |
| 29 | 2.4 | 2.3 | 2.7 |
| 30 | (New moon) 3.2 | 3.0 | 3.7 |

* All variations are positive.

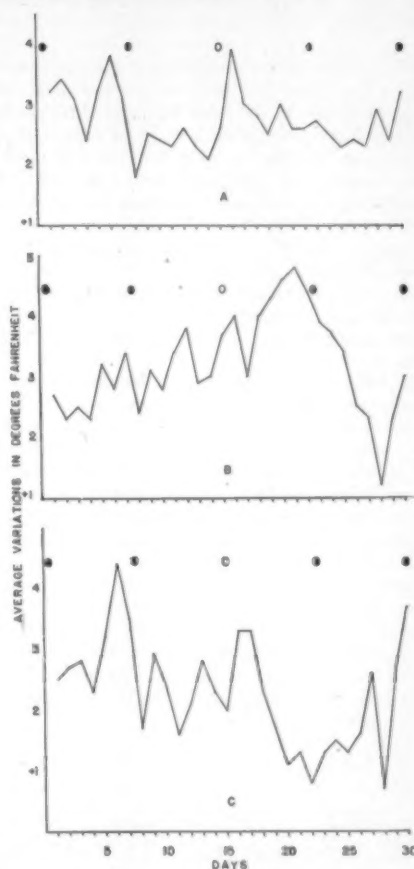


FIG. 1. Variations in mean daily temperature, arranged according to the day of the lunar month. Data from Jan. 1931, through Dec. 1946, Syracuse, N. Y. A, all lunar months; B, summer period, Apr. 20-Aug. 20; and C, winter period, Oct. 20-Feb. 20.

U. S. Dept. Commerce, Weather Bureau [1945]) from each of the mean daily temperatures, the variations were recorded according to the day of the lunar month. The data were then averaged (Table 1 [1]) and graphed (Fig. 1 A). Aside from the rise in mean temperatures just before the first quarter and just following the full moon, the variations were slight and seemed of little significance. It was then decided to analyze the data on a seasonal basis. Accordingly, the data were divided into a summer period (Apr. 20-Aug. 20) and a winter period (Oct. 20-Feb. 20). The data for the 30 days before and after the equinoxes were omitted.

The results were striking. During the summer

period (Fig. 1 *B*) there is a gradual increase in temperature from just prior to the new moon until a week after the full moon, followed by a relatively rapid fall of 4° within the next week. The lowest point is reached two days prior to the new moon. The situation during the winter period is not quite as clear-cut (Fig. 1 *C*). From just prior to the new moon until the first quarter, an irregular but marked rise in temperature takes place, over a range of approximately 4° . Between the first quarter and the full moon, a slump occurs, with a fairly distinctive high ending it immediately following the full moon. This slump is a crude inverse of the rise during the same interval of the summer period. Another marked slump follows, between the full moon high and the new moon, reaching its lowest point two days prior to the new moon. This slump is essentially the inverse of the rise that occurs during the summer period following the full moon.

The following features seem to be characteristic of temperature change during the lunar month: (1) an increase one or two days prior to the first quarter, (2) a marked general slump following the first quarter, (3) a slump at or just prior to the full moon, (4) a marked increase just following the full moon, followed in turn again by (5) a slump, and (6) the lowest point (during the summer and winter periods only) occurring just before the new moon. Since each of these rises or falls seems to occur without regard to time of year, they are probably influenced principally by the moon, but the summer rise and winter fall, particularly during the period of the last quarter, are influenced in part by the sun. The author has no desire to hazard a guess as to how these temperature changes are accomplished.

Although it is difficult to conceive of a person's senses being aware of these average changes, Mr. Littlefield's remark appears justified, in that a colder period seems consistently to have followed a full moon in winter. Likewise the adage that grain should be sown in the light of a full moon finds justification in the week or so of warmer weather that commonly follows a full moon in the summer period. As crude as the statistical techniques were, the results indicate that further research with defined methods would be of great interest.

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REFERRING to the paper by Herbert Henstock on "Minimum Night Temperatures at or Near Full Moon," I took an interest in this question over 20 years ago, when a friend remarked that the coldest weather of the month always came at full moon. At that time I was unable to corroborate this and concluded that it was just a superstition. This matter would be of considerable practical importance here, as we are subject to spring frosts that sometimes cause severe losses to the fruit crop.

Mr. Henstock's paper prompted me to re-examine

the question, and I have taken the U. S. Weather Bureau data for Yakima, Wash., for the period January 1949 to August 1952, and have plotted the daily minimum temperatures. This period included 45 full moons. I have also plotted the daily minimum temperatures for March, April, and May for the past 15 years, since this is the period when damaging frosts occur. This also included 45 full moons.

In each case, counting in the occasions when two equal falls occurred, one at full moon and one at some other time, the greatest fall came at full moon on only 20 occasions out of 45. Although this is more than would be expected, since the 6-day period around full moon is only about one fifth of the total time, it is far from being the rule. Of the 14 occasions of greatest fall at full moon during the past $3\frac{1}{2}$ years, 3 came in 1949, 8 in 1950, 3 in 1951, and none so far in 1952. Thus the distribution is erratic.

Weather Bureau records show we had damaging frosts in 1943, 1946, 1948, 1949 (three times), 1950, 1951, and 1952 (three times). Of these 11 occasions, the temperature fall causing them has occurred near full moon only 5 times. Evidently Henstock's theory does not apply very well here, and we could not count on it for predicting damaging frosts. Fortunately, we now have a very efficient frost-warning service provided by the Weather Bureau, so that such predictions are unnecessary.

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HENSTOCK has presented summaries of minimum night temperature falls at or near full moon for many places in the world and for three different years. The daily minimum temperatures allegedly show a regular fall at or near the date of full moon at each lunation. The temperature fall may be abrupt or gradual, and the downward trend does not always terminate on the date of full moon but sometimes within two or three days before or after.

Temperature records for 12 stations allegedly show the fall of minimum temperatures at or near full moon to be greater than the average yearly normal temperature fall at the same stations. If the average yearly normal temperature fall was determined from all the downward temperature trends during the year and compared with selected large ones that occurred near full moon, it is easy to see how consistent differences were obtained.

If the greatest minimum temperature fall is associated with full moon, then at other times during the lunar cycle the minimum temperature fall must be less. This hypothesis lends itself to statistical treatment of the data by several methods, one of which employs the greatest minimum temperature fall during comparable 7-day intervals. Thus, if the date of full moon is used as the midpoint of a 7-day interval, the interval would extend three days before and three days after full moon. According to Henstock, this interval should encompass the termination, if not all,

of the greatest minimum temperature falls at or near full moon. Similar intervals before and after the full moon period would provide suitable comparisons for statistical treatment of the data.

To test Henstock's hypothesis a 10-year temperature record was obtained from files in the University of California Experiment Station at Riverside. The dates of full moon from January 1942 through December 1951 were obtained from the *World Almanac*. Columns of minimum temperatures for the 10-year period were marked off in 7-day intervals so that each lunar cycle was divided into four 7-day intervals, with the third one centering on the date of full moon. The intervals would roughly coincide with the phases new moon, first quarter, full moon, and last quarter. One or two extra days each lunar month were not included in the intervals as marked on the tabulations of temperatures, but, as will become apparent, the temperatures on these extra days were considered in determining temperature fall.

The greatest fall in minimum temperature for the 7-day intervals during each year of the 10-year period was determined as follows: The greatest downward trend in minimum temperature for two or more consecutive days during each interval was tabulated. When the downward trend began in the previous interval or during the extra days mentioned above, the total downward trend was recorded for the interval in which the trend ended. Thus, the downward trend associated with full moon could start before the full moon interval but was required to end within it. Two or more consecutive days with the same minimum temperature

HENSTOCK's paper made no comparison of minimum night temperature falls at or near the full moon with falls at other times of the synodic period. It gave results of comparisons between the minimum temperature falls near the full moon and the average yearly falls for several stations. Such a comparison is not valid, since the term at or near full moon permits the analyst to include in the data minimum temperature falls that occur at varying times from the full moon phase. In other words, the analyst may continue looking for a fall in minimum temperature until one occurs, even though it occurs far from the full moon phase.

To determine if a greater number of minimum temperature falls occurred before, on, or after the full moon, records at three stations—Ottawa, Ont., Regina, Sask., and Edmonton, Alta.—for the years 1950 and 1951 were analyzed by recording the incidence of a

were not considered to terminate a downward trend in minimum temperature unless further fall did not occur. The same rules were followed in determining the fall in minimum temperature for each of the intervals, in order to eliminate any bias.

The greatest fall in minimum temperature for two weeks before, one week before, the week of, and the week after full moon were thus determined for each of the 12 or 13 full moons per year for the 10-year period (Table 1).

TABLE 1

| Intervals in relation to full moon | Greatest fall in minimum temperature (°F) (Means of 124 lunar cycles) |
|------------------------------------|--|
| 2 weeks before full moon | 10.40 |
| 1 week before full moon | 9.31 |
| Week of full moon | 9.86 |
| 1 week after full moon | 10.11 |

F-value = 1.03; P-value required for significance at 5% = 2.62.

An analysis of variance showed no significant difference in minimum temperature fall between the full moon interval and the other intervals; hence the data do not support the Henstock hypothesis that minimum temperature fall is the greatest at or near full moon.

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fall or rise in minimum temperatures for 13 days before, on, and 13 days after, the full moon phase. The trends in the data were scored on the day the fall or rise started. Ties were not included in the analysis. An example of the tables obtained is shown in Table 1.

Data for winter, spring, summer, and autumn were separately analyzed for both years and all locations,

TABLE 2

χ^2 FOR RISES AND FALLS OF MINIMUM NIGHT TEMPERATURES 1950, 1951, AND THEIR ASSOCIATED PROBABILITIES FOR 26 DEGREES OF FREEDOM, BY SEASONS, FOR REGINA, EDMONTON, AND OTTAWA

| | χ^2 | Probability |
|--------|----------|---------------|
| Winter | 15.42 | .90 < P < .95 |
| Spring | 17.27 | .90 < P < .95 |
| Summer | 18.09 | .80 < P < .90 |
| Autumn | 36.50 | .05 < P < .10 |

TABLE 1

FREQUENCY OF FALLS AND RISES OF MINIMUM TEMPERATURE DURING LUNAR MONTH
Edmonton 1950, 1951

| Day after full moon | -13, | -12, | _____ | -4, | -3, | -2, | -1, | 0, | 1, | 2, | 3, | 4, | _____ | 12, | 13 |
|---------------------|------|------|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|-----|----|
| No. of falls | 11, | 13, | _____ | 12, | 7, | 14, | 13, | 15, | 12, | 14, | 15, | 13, | _____ | 13, | 10 |
| No. of rises | 12, | 11, | _____ | 12, | 18, | 11, | 12, | 9, | 11, | 11, | 10, | 12, | _____ | 12, | 15 |

March 20, 1953

TABLE 3
 χ^2 FOR RISES AND FALLS OF MINIMUM NIGHT TEMPERATURES 1950, 1951, AND THEIR ASSOCIATED PROBABILITIES FOR 26 DEGREES OF FREEDOM, BY LOCATIONS, FOR ALL SEASONS

| | χ^2 | Probability |
|----------|----------|---------------|
| Regina | 27.37 | .30 < P < .50 |
| Edmonton | 16.90 | .90 < P < .95 |
| Ottawa | 31.31 | .20 < P < .30 |

first by the χ^2 test to determine if minimum temperature falls occurred more often on one day than on another. The results are shown in Table 2. For each of the seasons, the χ^2 test in Table 2 gave no evidence of

differences would appear between average minimum temperature falls for the phases of the moon. It will be noticed that in Table 4 only two of the six columns show a greater average fall at the full moon than at the other phases. In order to determine if any of these differences were statistically significant the data on which the above averages were based were analyzed by the analysis of variance.

From Table 5 it is apparent that in certain localities minimum temperature falls varied significantly from one part of the year to another. In only one instance did minimum temperature falls differ significantly between the phases (Regina, 1950), and in this instance the minimum temperature fall within 48 hr

TABLE 4
 AVERAGE GREATEST CONSECUTIVE FALL OF MINIMUM TEMPERATURES ($^{\circ}$ F) WITHIN 48 Hr OF THE MOON'S QUARTERS, BY STATIONS AND YEARS

| | Ottawa | | Regina | | Edmonton | |
|---------------|--------|-------|--------|-------|----------|-------|
| | 1950 | 1951 | 1950 | 1951 | 1950 | 1951 |
| Full moon | 6.67 | 13.92 | 8.50 | 12.83 | 8.83 | 11.17 |
| Last quarter | 9.25 | 9.92 | 10.00 | 13.00 | 7.25 | 10.42 |
| New moon | 8.00 | 11.75 | 14.08 | 10.92 | 9.17 | 10.25 |
| First quarter | 9.58 | 9.17 | 15.17 | 12.50 | 8.67 | 9.33 |

TABLE 5
 AN ANALYSIS OF VARIANCE OF GREATEST CONSECUTIVE FALL OF MINIMUM TEMPERATURES WITHIN 48 Hr OF THE MOON'S PHASES, BY STATIONS AND YEARS

| Source of variation | $^{\circ}$ F | Mean square | | | | | |
|---------------------|--------------|-------------|--------|--------|-------|----------|--------|
| | | Ottawa | | Regina | | Edmonton | |
| | | 1950 | 1951 | 1950 | 1951 | 1950 | 1951 |
| Between phases | 3 | 21.14 | 54.85 | 122.41 | 10.41 | 8.58 | 6.81 |
| Between periods | 11 | 74.71 | 137.55 | 99.92 | 58.11 | 15.16 | 125.63 |
| Error | 33 | 33.70 | 32.45 | 38.44 | 46.66 | 24.65 | 46.47 |

minimum temperature falls occurring more often on one day than on another.

The data were separately analyzed for both years and seasons by means of the χ^2 test to see if minimum temperature falls occurred more often on one day than on another during the lunar month. The results are shown in Table 3.

Since the χ^2 tests are based on data that record only the incidence of a fall or rise and not the magnitude, the minimum temperature falls within 48 hr of the full moon were compared with minimum temperature falls within 48 hr of the new, last, and first quarter phases of the moon. Records at Regina, Edmonton, and Ottawa for 1950 and 1951 were analyzed to determine if minimum night temperature falls within 48 hr of the full moon differed significantly from those at other times of the synodic period.

An analysis was made of the greatest consecutive fall of minimum temperatures within 48 hr of the phases of the moon for twelve synodic periods in 1950 and 1951 for Regina, Edmonton, and Ottawa. The data were obtained separately by stations and years by the analysis of variance to determine if any significant

of the full moon was not as much as that for the other phases of the moon.

On the basis of the data analyzed here there is no indication of any tendency for the greatest consecutive fall of minimum temperatures within 48 hr of the full moon to be significantly greater than falls for any other phase of the moon.

G. B. OAKLAND

Science Service, Department of Agriculture
 Ottawa, Canada

IN the article by Herbert Henstock there is a lack of definition of terms. The author speaks of a temperature drop at or near a full moon. Now, in the higher latitudes, there are periods of alternately rising and falling temperatures. Near every full moon there are, then, usually two periods of falling temperature. For instance, the minimum temperatures at Victoria during Apr. 1-7, 1947, inclusive, were 41 $^{\circ}$, 36 $^{\circ}$, 38 $^{\circ}$, 37 $^{\circ}$, 41 $^{\circ}$, 40 $^{\circ}$, 43 $^{\circ}$. (All Canadian temperatures are taken from *Monthly Record of Meteorological Observations in Canada and Newfoundland*, Department of Transport, Meteorological Division, Toronto.) Why

TABLE 1

| | Av temp fall near full moon - (Longley) | Av temp fall near full moon (Henstock) | Av normal Temp fall (Henstock) |
|-----------|---|--|--------------------------------------|
| Victoria | 4.4 | 5.0 | 4.7 |
| Old Glory | 11.8 | 11.8 | 10.3 |
| Aklavik | 9.9 | 15.7 | 9.5 |
| Banff | 18.2 | 19.7 | 14.6 |

did the author, with the full moon on Apr. 5, select the drop of 5° between Apr. 1 and Apr. 2, rather than the drop of 1° between Apr. 3 and Apr. 4, or the drop between Apr. 5 and Apr. 6? The minimum temperatures at Banff Jan. 1-9 were, respectively, -19° , -13° , -3° , 11° , -4° , 3° , 13° , 12° , 19° , and the full moon was on Jan. 8. The author picks the drop between 11° and -4° , rather than the one between 13° and 12° . At Aklavik, the minimum temperatures from Feb. 27 to Mar. 5 were -12° , -6° , -24° , -20° , -40° , -40° , -28° . The author refers to a drop of 34° between Feb. 28 and Mar. 3, ignoring the rise between Mar. 1 and 2. With no apparent consistent practice in selecting periods of falling temperature, it is difficult to assure oneself of the validity of Henstock's results.

One could, with reason, define the fall near or at the full moon as follows: If the temperature on the day of the full moon is associated with a period of falling temperatures, in the middle or at either end, that period is to be selected; if the day is found within a period of rising temperatures, the last fall preceding the full moon is to be selected. Using that definition, the average fall was computed for the 13 full moons of 1947. The values are given in Table 1. Also included are the values obtained by Henstock, and his "average yearly normal temperature falls." The latter he does not define clearly, nor does he show the source of his data.

The new set of figures still suggests that the fall of temperature near a full moon is greater than normal, but the evidence is not so overwhelming.

The question could be handled in another manner. There were available average daily changes in minimum temperature at a number of Canadian stations (See Longley, R. W. *The Daily Variation in Temperature*, Technical Circ. No. 81. Meteorological Division, Department of Transport, Toronto [Feb. 1951]). The drops in temperature during the periods of falling temperature near the full moon at some of these stations were compared with the average daily change for part of the year 1947. Out of 165 cases noted, the drop in temperature per day near the full moon was less than the average daily change in temperature in 84 cases, and greater in 81 cases. This does not appear to bear out the hypothesis that the drops in temperature near the full moon are extreme.

RICHMOND W. LONGLEY

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March 20, 1953

HENSTOCK has reported that the minimum temperatures recorded at several widely scattered stations seem to be related to the phase of the moon. His findings are in sharp disagreement with accepted meteorological knowledge; hence careful analysis of his paper seems to be imperative.

Unfortunately the data and methods employed by Henstock appear to invalidate his findings from the start. The acceptance of his results even as a working hypothesis for further research is not warranted. His data, at most 5 years at one station and single years at the others, are absolutely insufficient in any attempt to evaluate such effects as lunar influences. It should be pointed out that, for example, the establishment of the magnitude of the lunar tide in the atmospheric pressure—which can be shown to exist theoretically—necessitated the use of about 350,000 observations even in tropical latitudes, where the other random effects upon the pressure are small! When dealing with minimum temperatures we must contend with large random effects introduced by air mass changes, variations of insolation, and other factors, which result in a large standard deviation of such temperature values. From the 78-year record of minimum temperature at Boston, Mass., the standard deviation was computed for January to be 10.2° F; and the order of magnitude of this standard deviation is about representative for all stations in temperate latitudes.

From such figures it can be deduced that interdiurnal changes of 10 or more $^{\circ}$ F are by no means rare occurrences. To obtain significant results for changes of this same order of magnitude, at least several decades of records must be employed. Utilizing 20 years of data from the Boston record, no relationship of minimum temperatures to moon phases could be found. Any attempt to gain more confidence in the results by using more stations is doomed to failure, because the same arguments are valid for other stations also.

Even if the results could be assumed to be statistically significant, they do not necessarily imply any relation to moon phases. Several other explanations are possible. We can compute theoretically the possible stable, free oscillations of the atmosphere. One such wave has a period of about 30 days, and in several papers the actual existence of this wave in meteorological phenomena and its long persistence (of the order of a year or more) have been proved. Such waves in the general circulation of the atmosphere can also be reflected in single elements as temperature, etc. Thus it seems quite possible that it is not the revolution of the moon (the synodic month has a length of approximately 29½ days) that is responsible for the recurrence of low temperatures in intervals of about 29-30 days, but that this is actually a reflection of the free oscillation inherent in our atmosphere in the temperature records of single stations.

Another possible explanation may lie in the often found quasi-persistent recurrence of weather patterns

with periods of 7-8 days, and we must take into account possible solar influences geared to the solar rotation with a periodicity of about 27-28 days.

This list of points is by no means complete, but it is sufficient to show the difficulties encountered if the attempt is made to investigate lunar influences upon the weather. Very elaborate statistical procedures must be employed before even preliminary results of sufficient significance can be obtained. For this reason the results and implications of Mr. Henstock's paper are not acceptable. In general, meteorologists still

agree that lunar influences upon meteorological elements other than the tidal waves—which are extremely small—have not been adequately demonstrated. Many papers have been published alleging to show such influences, but up to now none has held up under a careful and unbiased scrutiny.

EBERHARD W. WAHL

*Atmospheric Analysis Laboratory
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Air Force Cambridge Research Center
Cambridge, Massachusetts*

Book Reviews

The Genetics of the Dog. Marica Burns. Farnham Royal, Bucks, Eng.: Commonwealth Agricultural Bureaux, 1952. 122 pp. and plates. 12s 6d.

Marica Burns is a geneticist as well as a dog breeder, and this little book amply proves the connection. It contains a digest of the world's technical studies of dog genetics, yet is written for the layman with a background of college biology.

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The book contains many interesting halftones and line drawings, a glossary, and a 240-item bibliography.

LEON F. WHITNEY

*Oakwood Road
Orange, Connecticut*

Investment Castings for Engineers. Rawson L. Wood and Davidlee Von Ludwig. New York: Reinhold Pub., 1952. 477 pp. Illus. \$10.00.

The purpose of this text is to acquaint design engineers with the investment process, to help him obtain maximum efficiency and economy from his design and specifications. When selecting a process by which an engineering part is to be produced, the designer weighs all the factors affecting function and cost. In order to do this most effectively he should have more than a general knowledge of all the prospective processes. Also, because of lack of knowledge of a process, a designer may avoid it and consequently not obtain the best results from his design.

After determining the process to be used, an efficient design engineer must have an intimate knowledge of the process so that the part may be designed for most economical production. The text therefore describes the various investment processes in detail. It points out how the various steps in the production of

the casting are related to design. For example, in discussing the factors influencing the positioning of the gate, the designer finds that he cannot expect to obtain tolerances less than 0.010 inch near the gate area. In the discussion on "Factors Affecting Die Life," he points out that thin design sections necessitate the use of hardened steel dies in the production of wax patterns, because of higher temperatures needed to produce such sections.

After a brief history of investment casting, the text continues with the production of the master pattern, describing various types of dies obtained from it. This is followed by a very thorough discussion of types of patterns in use. One chapter deals with the "Frozen Mercury Disposable Pattern," a development not too familiar to the average engineer. Information on investment materials and techniques used in producing molds follows, and after a brief description of the melting techniques, the text deals quite thoroughly with ferrous and nonferrous metals used in investment casting. This is followed by information on cleaning, inspecting, and finishing of the castings. The next 90 pages deal with design of castings for the investment process. The last two chapters treat the metallurgical effect of the process on metals, and machinability tests on stainless steels.

C. T. MAREK

Department of Engineering, Purdue University

Scientific Book Register

Thermal Diffusion in Gases. K. E. Grew and T. L. Ibbs. New York: Cambridge Univ. Press, 1952. 143 pp. Illus. \$4.50.

The Philosophy of Science: An Introduction. Stephen Toulmin. London: Hutchinson's Univ. Library; New York: Longmans, Green, 1953. 176 pp. Illus. \$2.25; text ed. \$1.80.

Scientific Terminology. (Medical, biological, and general.) John N. Hough. New York: Rinehart, 1953. 231 pp. \$3.50.

The Microbiological Assay of the Vitamin B-Complex and Amino Acids. E. C. Barton-Wright. New York-London: Pitman, 1952. 179 pp. Illus. \$4.00.



An INTRODUCTION to LINEAR PROGRAMMING

By A. CHARNES, W. W. COOPER, and A. HENDERSON, *all at the Carnegie Institute of Technology*. Presented in this new book is a modern tool for planning and analysis, designed to aid in scheduling and analyzing business activity involving simultaneous attention to many interacting considerations. A simple, concrete numerical problem is developed with accompanying explanations and economic interpretations. 1953. 74 pages. \$2.50.

AFRICA: A Study in Tropical Development

By L. DUDLEY STAMP, *President, International Geographical Union*. This book surveys the continent as a whole, expertly weighing the geographical factors which have contributed to its development or lack of development, and exploring every facet of African life. It examines not only the relationship of Africa's geography to its social, political and economic welfare, but also looks into the *real* causes behind the growth of African independence. 1953. 568 pages. \$8.50.

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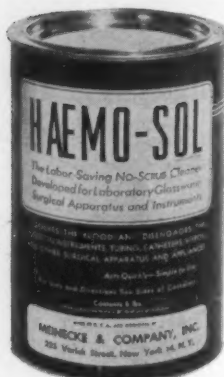
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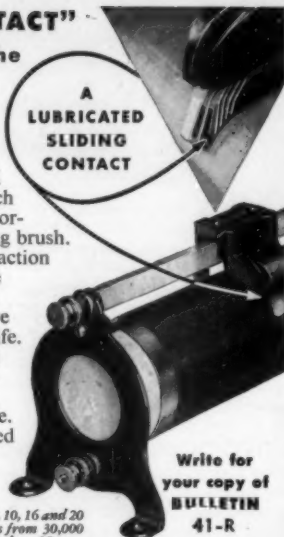
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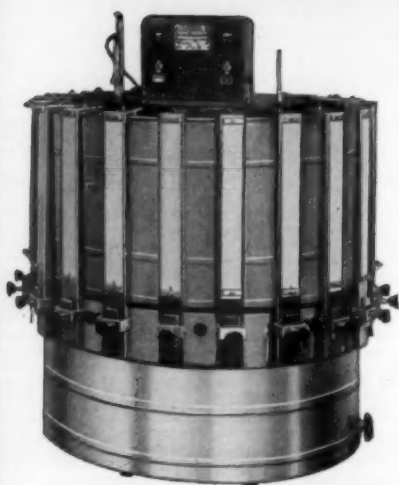
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- Mar. 26-28. American Physical Society. Durham and Chapel Hill, N. C.
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- Mar. 27. Association for Research in Ophthalmology, Midwestern Section. Oscar Johnson Institute, St. Louis.
- Mar. 29-Apr. 1. Society of German Chemists, Union of Austrian Chemists, and Swiss Chemical Society (Chemical Meeting). Innsbruck.
- Mar. 30-31. Symposium on Retinal Diseases. Department of Ophthalmology, College of Medicine, State University of Iowa, Iowa City.
- Mar. 30-Apr. 2. Association of American Geographers (Annual). Cleveland.
- Mar. 31-Apr. 2. International Magnesium Exposition. National Guard Armory, Washington, D. C.
- Apr. 1-3. American Surgical Association. Hotel Statler, Los Angeles.
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- Apr. 6-10. American Physiological Society (Spring). Chicago.
- Apr. 6-10. Federation of American Societies for Experimental Biology (Annual). Chicago.
- Apr. 8-12. American Heart Association (Annual). Hotel Chelsea, Atlantic City.
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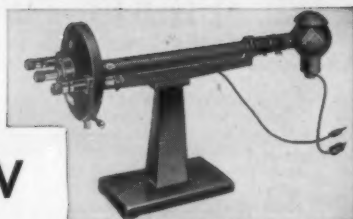
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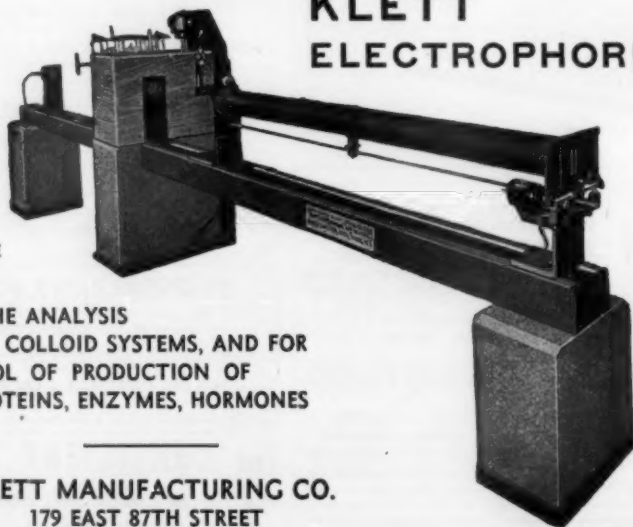
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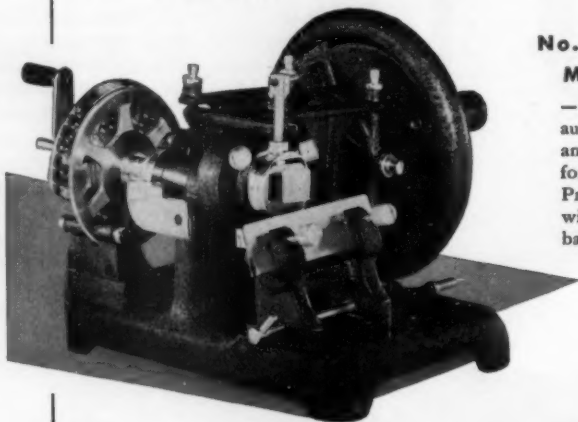


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